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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 11 (OU 11) SITE 45 STEAM GENERATING PLANT NAS CECIL FIELD FL

8/20/2001

TETRA TECH NUS INC

Feasibility Study Report
for
Operable Unit 11, Site 45
Steam Generating Plant

Naval Air Station Cecil Field
Jacksonville, Florida

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888

Contract Task Order 0078

August 2001

FEASIBILITY STUDY REPORT
FOR
OPERABLE UNIT 11, SITE 45
STEAM GENERATING PLANT

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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This document that describes the Feasibility Study Report for Operable Unit 11, Site 45, Steam Generating Plant, Naval Air Station Cecil Field, Jacksonville, Florida, has been prepared under the direction of a Florida-registered professional engineer. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice.

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	microgram(s) per liter
ABB-ES	ABB Environmental Services, Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
BaPEq	benzo(a)pyrene equivalent
BCT	BRAC Closure Team
bgs	below ground surface
BOD	biochemical oxygen demand
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CKD	cement kiln dust
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	chemical of concern
cPAH	carcinogenic polynuclear aromatic hydrocarbon
CSF	Cancer Slope Factor (USEPA's)
CTO	Contract Task Order
CWA	Clean Water Act
DO	dissolved oxygen
DOT	Department of Transportation
EBCT	empty bed contact time
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FS	Feasibility Study
ft	foot or feet
ft^2	square foot or square feet
ft^3	cubic foot or cubic feet
GAC	granular activated carbon
GCTL	Groundwater Cleanup Target Levels (FDEP's)
gpm	gallon(s) per minute
GRA	General Response Action
HLA	Harding Lawson Associates
HQ	Hazard Quotient
IBDS	Inorganic Background Data Set
IWTP	industrial wastewater treatment plant

KAG	Kerosene Analyte Group (FDEP's)
LTTD	low-temperature thermal desorption
LUC	land use control
LUCIP	Land Use Control Implementation Plan
MCLs	Maximum Contaminant Levels (USEPA's)
mg/L	milligram(s) per liter
msl	mean sea level
NAS	Naval Air Station
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPW	net present worth
O&M	operation and maintenance
ORP	oxidation/reduction potential
OSHA	Occupational Safety and Health Act
OU	Operable Unit
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbon
POTW	publicly-owned treatment works
PPE	personal protection equipment
PRB	permeable reactive barrier
PRE	Preliminary Risk Evaluation
PRG	Preliminary Remedial Action Goal
PSC	Potential Source of Contamination
RAO	Remedial Action Objective
RBC	risked-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose (USEPA's)
RI	Remedial Investigation
SCTL	Soil Cleanup Target Level (FDEP's)
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level (USEPA's)
SOUTHDIVNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SPECAP	specific capacity (test)
STP	sewage treatment plant
SWMU	solid waste management unit
TAL	Target Analyte List
TBC	To Be Considered (criterion)

TCE	trichloroethene
TCL	Target Compound List
TOC	total organic carbon
TRPH	Total Recoverable Petroleum Hydrocarbons
TSDF	treatment, storage, disposal facility
TSS	total suspended solids
TtNUS	Tetra Tech NUS, Inc.
UCL	upper confidence limit
USCS	United Soil Classification System
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UST	Underground Storage Tank
VOCs	volatile organic compounds
yd^3	cubic yard(s)

EXECUTIVE SUMMARY

E.1 PURPOSE OF THE REPORT

The purpose of this Feasibility Study (FS) Report is to develop and evaluate options for the remediation of contaminated soil and groundwater for Operable Unit (OU) 11, Site 45, Steam Generating Plant (Site 45) at Naval Air Station (NAS) Cecil Field in Jacksonville, Florida.

E.2 SITE DESCRIPTION AND HISTORY

Site 45 - Steam Generating Plant, is located north of the Crossover Street (formerly Second Street) and east of the Authority Avenue (formerly "C" Avenue). The site includes Buildings 2, 7, 11, and 12, and the adjacent land area. Building 2 is an administrative office, Building 7 was a Flammable and Hazardous Materials Storage Building. Building 11 was the Steam Generating Plant, and Building 12 was the Operations Training Building. The site is primarily unpaved and covers an area of about 2 acres. The south border is Crossover Street, the west border is Authority Avenue, the north border is Skillside Street (formerly Third Street), and the east border is a parking lot. There are also parking lots adjacent to the buildings along Crossover Street, Skillside Street, and Authority Avenue.

The oldest Site 45 buildings (Buildings 11 and 12) date back from 1941 and the newest (Building 7) dates from 1989. Buildings 2 and 12 have always been used for administrative functions. Building 7 has always been used to store the chemicals used in Building 11. Building 11 generated steam for the entire base but, following NAS Cecil Field closure in September 1999 and transfer of the base to civilian ownership, the steam generating facility has been de-activated.

The name of the site has been changed over the course of the investigations. For the Environmental Baseline Study investigation, the site was designated as Facility 11. When it was determined that soil contamination was over a large area, the area was re-designated Potential Source of Contamination (PSC) 45 in January 1999. When the presence of groundwater contamination was confirmed, the area was designated as Installation Restoration (IR) Site 45 in February 2000.

Several environmental investigations were performed at Site 45, starting with the Base Realignment and Closure (BRAC) Phase II investigation of Building 7 in November 1995 through the RI of Site 45 in April 2000 and the post-RI groundwater sampling of March 2001. These investigations showed that soil was contaminated with polynuclear aromatic hydrocarbons (PAHs), total recoverable petroleum hydrocarbon (TRPH), arsenic, mercury, and vanadium. Soil contaminated in excess of industrial exposure criteria was excavated and disposed off-site in August 2000. These investigations also showed that groundwater is

contaminated with lead and vanadium and evaluation of that contamination was the primary objective of the RI.

E.3 SUMMARY OF THE INVESTIGATIONS FINDINGS

Total Recoverable Petroleum Hydrocarbons (TRPH), benzo(a)pyrene equivalents (BaPEq), and arsenic were detected in soil at concentrations in excess of the Florida Department of Environmental Protection (FDEP) Soil Cleanup Target Levels (SCTLs) for direct residential exposure. Soil contamination extends over an area approximately 2.8 acres in size and down to a depth of 2 feet (ft) below ground surface (bgs).

Vanadium was detected in several groundwater samples at concentrations greater than the FDEP Groundwater Cleanup Target Level (GCTL) of 49 micrograms per liter (µg/L) (FDEP, 1999a). The horizontal extent of the vanadium contaminant plume, as defined by exceedances of the GCTL, was determined to be approximately 260 ft by 110 ft. The vertical extent of contamination did not exceed approximately 35 ft bgs.

The Preliminary Risk Assessment (PRE) performed as part of the RI identified TRPH, BaPEq, and arsenic as chemicals of concern (COCs) for the Site 45 soil and vanadium as COC for the Site 45 groundwater. The PRE indicated that, although concentrations of vanadium detected in the groundwater were below the United States Environmental Protection Agency (USEPA) Region 9 tap water Preliminary Remediation Goal (PRG) of 260 µg/L (USEPA, 2001), exposure to contaminated groundwater could still result in adverse health effects under an hypothetical future residential scenario.

The ecological risk assessment performed as part of the RI established that Site 45 consists primarily of buildings and parking lots which provides an ecological habitat of marginal quality that can be of little use to terrestrial wildlife. Therefore, the RI concluded that Site 45 does not present any significant ecological risk.

E.4 REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL ACTION GOALS

The Remedial Action Objectives (RAOs) identified for Site 45 are as follows:

- Prevent unacceptable risk from exposure to soil with concentrations of BaPEq, and TRPH in excess of the FDEP residential SCTLs and arsenic in excess of the NAS Cecil Field site-specific Inorganic Background Data Set (IBDS) (HLA, 1998c).

- Prevent unacceptable risk from ingestion of groundwater with concentrations of vanadium in excess of the FDEP GCTL.

The Preliminary Remedial Action Goals (PRGs) for the site 45 soil are as follows:

COC	PRGs
BaPEq	100 µg/kg(1)
Arsenic	2.04 mg/kg(2)
TRPH	340 mg/kg(1)

(1) FDEP SCTLs for direct residential exposure (FDEP, 1999a)

(2) NAS Cecil Field site-specific IBDS (HLA, 1998c)

The PRG for vanadium in the Site 45 groundwater is 49 µg/L, which is the FDEP GCTL.

E.5 SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIATION TECHNOLOGIES, AND PROCESS OPTIONS

General Response Actions (GRAs) and the remediation technologies and process options associated to these GRAs were screened for effectiveness, implementability and cost. Remediation technologies that were determined to be ineffective or too difficult to implement were eliminated from further consideration.

The following technologies and process options were retained for the Site 45 soil:

General Response Action	Remedial Technology	Process Options
No Action	None	Not Applicable
Limited Action	Institutional Controls	Passive: Land Use Controls (LUCs)
	Monitoring	Sampling and Analysis
Removal	Excavation	Excavation
Ex-Situ Treatment	Physical/Chemical	Chemical Fixation/Stabilization
		Crushing/Grinding/Shredding
	Thermal	Off-Site Low-Temperature Thermal Desorption (LTTD)
Disposal	Off-Base Disposal	Solid Waste Disposal Facility

The following GRAs, remediation technologies, and process options were retained to develop groundwater remedial alternatives for Site 45:

General Response Action	Remediation Technology	Process Options
No Action	None	Not Applicable
Limited Action	Monitoring	Sampling and Analysis
	Institutional Controls	LUCs and groundwater use restrictions
	Natural Attenuation	Dispersion and Dilution
Removal	Groundwater Extraction	Extraction Wells
Ex-situ Treatment	Physical	Filtration
	Chemical	Ion Exchange
Discharge/Disposal	Onsite Surface Discharge	Direct Discharge (NPDES)

E.6 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The following remedial alternatives were assembled for the Site 45 soil:

- **Alternative 1: No Action.** No action would be taken. Retained as a baseline for comparison with other alternatives.

- **Alternative 2: Institutional Controls and Monitoring.** Institutional controls would consist of implementing Land Use Controls (LUCs) to prevent future residential development. Monitoring would consist of long-term soil and groundwater sampling and analysis to evaluate potential migration of contaminants from soil to groundwater.

- **Alternative 3: Excavation and Off-Base Treatment and Disposal.** This alternative would consist of excavating the soil contaminated above the FDEP SCTLs for direct residential exposure or IBDS and backfilling the excavated area with clean soil. The excavated soil would be transported off-base to a permitted treatment, storage, and disposal facility (TSDF) for treatment by such technologies as chemical fixation/solidification and/or low temperature thermal desorption (LTTD) and disposal through landfilling. Treatment would be preceded, if necessary, by size-reduction with crushing, grinding, and shredding.

The following remedial alternatives were developed for the Site 45 groundwater:

- **Alternative 1: No Action**. No action would be taken. Retained as a baseline for comparison with other alternatives.

- **Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring**. Natural attenuation would consist of implementing a long-term groundwater sampling and analysis program to evaluate the reduction in the concentrations of groundwater COCs through naturally-occurring processes. Institutional controls would consist of implementing LUCs and preventing the use of groundwater until

the vanadium PRG has been met. Monitoring would consist of regularly collecting and analyzing groundwater samples both from within the contaminant plume to assess natural attenuation and downgradient of leading edge of the plume to evaluate potential contaminant migration.

- **Alternative 3: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring**. This alternative would consist of extracting the contaminated groundwater through four new extraction wells, each pumping at the rate of 5 gallons per minute (gpm). The extracted groundwater would be treated by ion exchange to remove dissolved vanadium prior to discharge to surface water. Institutional controls would be the same as for Alternative 2. Monitoring would also be the same as for Alternative 2 with the in-plume groundwater sampling and analysis being used to evaluate the progress of the extraction and treatment process.

E.7 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were analyzed in detail using seven of the nine criteria provided in the National Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). These seven criteria are as follows:

- Overall Protection of Human Health and the Environment,
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBCs) guidance criteria,
- Long-term Effectiveness and Permanence,
- Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment,
- Short-term Effectiveness,
- Implementability, and
- Cost

Two other criteria, State and Community Acceptance were not evaluated in this report. They will be evaluated after regulatory and public comments are available.

E.8 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were compared to each other using the same criteria that were used for detailed analysis. The following is a summary of these comparisons:

Soil

- **Overall Protection of Human Health and Environment**

Alternative 1 would not be protective of human health and the environment since COCs would remain above SCTLs for direct residential exposure or IBDS and residential development could occur. Also, the potential would remain for soil COCs to migrate to groundwater and no monitoring would be performed to detect this potential migration. Although it would not actively remove contaminants, Alternative 2 would be protective of human health and the environment because institutional controls would prevent residential development and monitoring would evaluate possible migration of soil COCs. Alternative 3 would be most protective of human health and the environment since all soil contaminated above SCTLs for direct residential exposure or IBDS would be physically removed from the site and effectively and irreversibly treated and disposed off-base.

- **Compliance with ARARs and TBCs**

Alternative 1 would not comply with chemical- or location-specific ARARs and TBCs. No action-specific ARARs or TBCs would apply to this alternative. Alternative 2 would comply with location- and action-specific ARARs and TBCs but not with chemical-specific ARARs and TBCs since contaminants would remain on site. Alternative 3 would comply with the chemical-, location-, and action-specific ARARs and TBCs.

- **Long-term Effectiveness and Permanence**

Alternative 1 would have no long-term effectiveness and permanence since no action would be taken to reduce soil contamination, or control exposure to contaminated soil, or monitor possible migration of contaminants from soil to groundwater. Alternative 2 would have some long-term effectiveness and permanence because institutional controls would prevent unacceptable risk from exposure to contaminated soil and monitoring would warn of possible migration of COCs from soil to groundwater. Alternative 3 would have the best long-term effectiveness and permanence since it would permanently remove from the site the soil contaminated above PRGs and permanently and irreversibly treat and dispose of the removed soil.

- **Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment**

Alternatives 1 and 2 would not reduce contaminant toxicity, mobility, or volume through treatment. Under these alternatives some reduction of contaminant toxicity and volume might occur through natural attenuation but only Alternative 2 would monitor this reduction. Alternative 3 would reduce contaminant

toxicity, mobility, and volume through treatment. Under this alternative 7,800 cubic yards (yd^3) of soil containing approximately 1,604 pounds of COCs would be permanently removed from the site.

- **Short-term Effectiveness**

There would be no short-term effectiveness concerns associated with Alternative 1 since no action would be taken. Alternative 2 would have minimal short-term effectiveness concerns associated with the collection of soil and groundwater samples. These concerns would be effectively addressed by adherence to a site-specific Health and Safety Plan (HASP), including the wearing of the appropriate personal protection equipment (PPE). Alternative 3 would have significant short-term effectiveness concerns because excavation and off-base transportation, treatment, and disposal would involve a significantly greater opportunity of exposure of remediation workers to contaminated soil. Because of off-base transportation, Alternative 3 would also have the potential to impact the surrounding community. However, the short-term concerns associated with Alternative 3 could be adequately addressed through implementation of proper engineering controls and adherence to applicable OSHA regulations and to the site-specific HASP, including the wearing of appropriate PPE.

Alternative 1 would not achieve the RAOs and, although the soil PRGs might eventually been attained through natural attenuation, there would be no means of verifying it. Alternative 2 would achieve the RAOs immediately upon implementation of institutional controls and monitoring and might eventually attain soil PRGs through natural attenuation as verified through monitoring. Alternative 3 would attain soil the RAOs and PRGs within an estimated 2 months of start of excavation.

- **Implementability**

Alternative 1 would be easiest to implement since there would be no activities to implement.

Technically, the monitoring component of Alternative 2 would be very simple to implement. Alternative 3 would be hardest to implement because, although it does not include long-term monitoring, it would require a closely-coordinated multi-stage operation for the excavation, off-base transportation, off-base treatment, and disposal of contaminated soil. However, the necessary resources for implementation of the activities of this alternative are readily available and adequate measures could be taken to minimize impact on existing site structures and activities.

Administratively, the institutional controls component of Alternative 2 would be simple to implement. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of land use restrictions and monitoring. The administrative implementability of Alternative 3 would be somewhat more difficult than

that of Alternative 2 as it would require construction permits, manifesting of the excavated soil for off-base transportation, and acceptance of the excavated soil by the off-base TSDF. However, these requirements could be readily implemented.

- **Cost**

The capital and operation and maintenance (O&M) costs and net present worth (NPW) of the soil remedial alternatives were estimated to be as follows:

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
1	0	0	0
2	25,000	161,000	186,000
3	3,900,000	0	3,900,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates. A detailed breakdown of cost estimates is provided in Appendix C.

Groundwater

- **Overall Protection of Human Health and Environment**

Alternative 1 would not be protective of human health and the environment since vanadium would remain above its PRG, no institutional controls would be implemented to prevent unacceptable risk from ingestion of contaminated groundwater, and no monitoring would be performed to evaluate the progress of natural attenuation or the potential migration of contaminants.

Alternative 2 would be protective of human health and the environment. Although no active remediation would take place, natural attenuation would dissipate the contaminant plume, institutional controls would prevent unacceptable exposure to contaminated groundwater, and monitoring would evaluate the progress of natural attenuation and verify that unacceptable migration of contaminants is not taking place.

Alternative 3 would be more protective of human health and the environment than Alternative 2 because, in addition to institutional controls and monitoring, this alternative would accelerate the remediation of the site through active removal and treatment processes. This alternative would extract and treat groundwater from the contaminant plume and thus control expansion of the plume, which would be verified through monitoring.

- **Compliance with ARARs and TBCs**

Alternative 1 would not comply with chemical- or location-specific ARARs and TBCs. No action-specific ARARs or TBCs would apply to this alternative. Alternatives 2 and 3 would comply with location- and action-specific ARARs and TBCs and, eventually, with chemical-specific ARARs and TBCs as well. It is anticipated that compliance with chemical-specific ARARs and TBCs would first be achieved by Alternative 3.

- **Long-term Effectiveness and Permanence**

Alternative 1 would have no long-term effectiveness and permanence since no action would be taken to reduce contamination, or control exposure to contaminated groundwater, or monitor progress of natural attenuation and detect potential migration of contaminants.

Alternative 2 would have long-term effectiveness and permanence because institutional controls and monitoring would effectively prevent unacceptable exposure to contaminated groundwater until the vanadium PRG has been met through natural attenuation.

Alternative 3 would be more long-term effective and permanent than Alternative 2 because, in addition to controlling risk of unacceptable exposure and monitoring the progress of natural attenuation and the possibility of contaminant migration, this alternative would effectively and irreversibly remediate the contaminant plume through a proven means (i.e., extraction and treatment) to achieve the vanadium PRG

- **Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment**

Alternatives 1 and 2 would not reduce contaminant toxicity, mobility, or volume through treatment. Under these alternatives, contaminant toxicity and volume would be reduced through natural attenuation but only Alternative 2 would monitor this reduction.

Alternative 3 would significantly reduce contaminant toxicity and volume through treatment. The treatment system of Alternative 3 would be designed to remove an estimated 3.1 pounds of vanadium from the contaminant plume through its operating life. The contaminant removal achieved by this alternative would be 100 percent irreversible.

- **Short-term Effectiveness**

There would be no short-term effectiveness concerns and no impact to the surrounding community associated with Alternative 1 since no action would be taken.

Alternatives 2 and 3 would also not impact the surrounding community but there would be some short-term effectiveness concerns associated with their implementation because of the risk of workers being exposed to contaminated groundwater. The magnitude of this risk would be proportional to the extent of remedial activities, e.g., it would be minimal for Alternative 2 and significant for Alternative 3. However, regardless of its magnitude, the risk of exposure would be properly mitigated through implementation of proper engineering controls, and adherence to applicable OSHA regulations and to the site-specific health and safety procedures, including the wearing of appropriate personal protective equipment (PPE).

Alternative 1 would not achieve the RAO and, although the vanadium PRG would eventually be attained through natural attenuation, there would be no means of determining when this had occurred. Alternatives 2 and 3 would achieve the RAO immediately upon implementation of institutional controls. It is estimated that Alternatives 2 and 3 would attain the vanadium PRG within 900 to 1,300 years and 18 years, respectively.

- **Implementability**

Alternative 1 would be easiest to implement since there would be no activities to implement.

Technically, the monitoring component of Alternatives 2 and 3 would be relatively simple to implement.

The technical implementability of Alternative 3 would be slightly more difficult than that of Alternative 2 because, in addition to monitoring, this alternative would require the installation and operation and maintenance of a relatively small groundwater extraction and on-site treatment systems (20 gpm).

Alternatives 2 and 3 would be administratively implementable. The institutional controls component of these alternatives would be simple to implement. As part of the transfer of property from military to private ownership, appropriate provisions will be incorporated in the property transfer documents to ensure continued enforcement of controls. Alternative 3 would require construction permits for the installation of extraction wells and an on-site treatment system. Alternative 3 would also have to meet the substantive requirements of an NPDES permit for discharge of treated groundwater to surface water. All of these requirements would be readily implementable.

- **Cost**

The capital O&M costs and NPW of the groundwater remedial alternatives were estimated to be as follows:

Alternative	Capital ($)	30-year NPW of O&M ($)	30-year NPW ($)
1	0	0	0
2	25,000	122,000	147,000
3	303,000	393,000 (18 Years)	696,000 (18 Years)

A detailed breakdown of cost estimates is provided in Appendix C.

1.0 INTRODUCTION

This Feasibility Study (FS) report for Operable Unit (OU) 11, Site 45, Steam Generating Plant at Naval Air Station (NAS) Cecil Field, Jacksonville, Florida has been prepared by Tetra Tech NUS, Inc. (TtNUS) for Southern Division Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM) under the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0078. This FS report describes the formulation and evaluation of remedial alternatives for contaminated soil and groundwater at Site 45.

The FS was conducted to establish Remedial Action Objectives (RAOs) and Preliminary Remedial Action Goals (PRGs); screen remedial technologies; and assemble, evaluate, and compare remedial alternatives.

1.1 SITE BACKGROUND

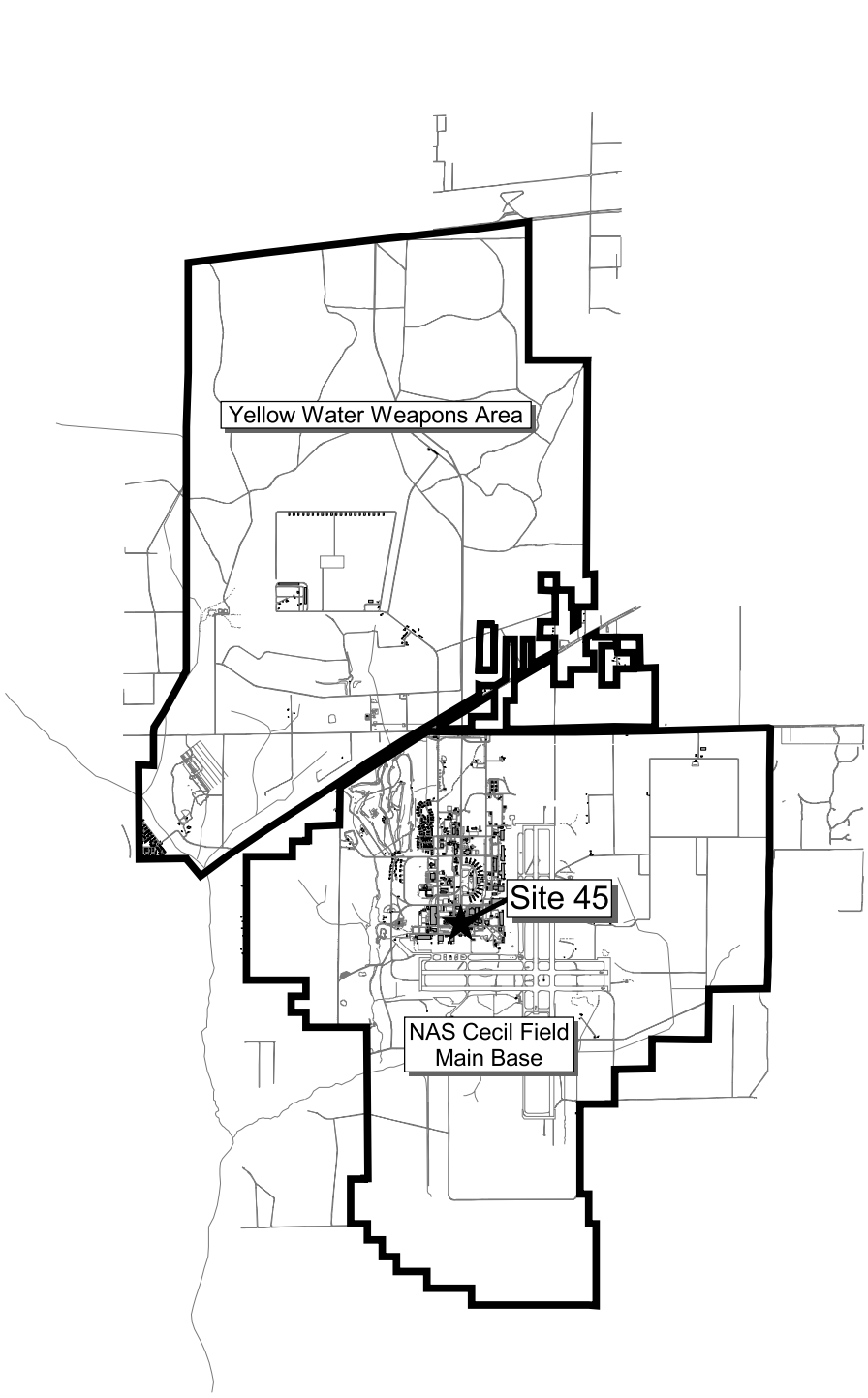
The following paragraphs describe the background of Site 45. Figure 1-1 provides a site location map. Figure 1-2 shows the vicinity of the site. Figure 1-3 provides the current general arrangement of the site.

1.1.1 Site Description

Site 45 - Steam Generating Plant, is located north of the Crossover Street (formerly Second Street) and east of the Authority Avenue (formerly “C” Avenue). Investigations at the site were originally focused on Buildings 7 and 11. The site includes Buildings 2, 7, 11, and 12, and the adjacent land area [Harding Lawson Associates (HLA), 1999c]. Three above ground storage tanks and a concrete containment area are located on the east side of Building 11. An underground storage tank (UST) was located to the south of Building 11, but was removed in 1986 [ABB-Environmental Services, Inc. (ABB-ES), 1994].

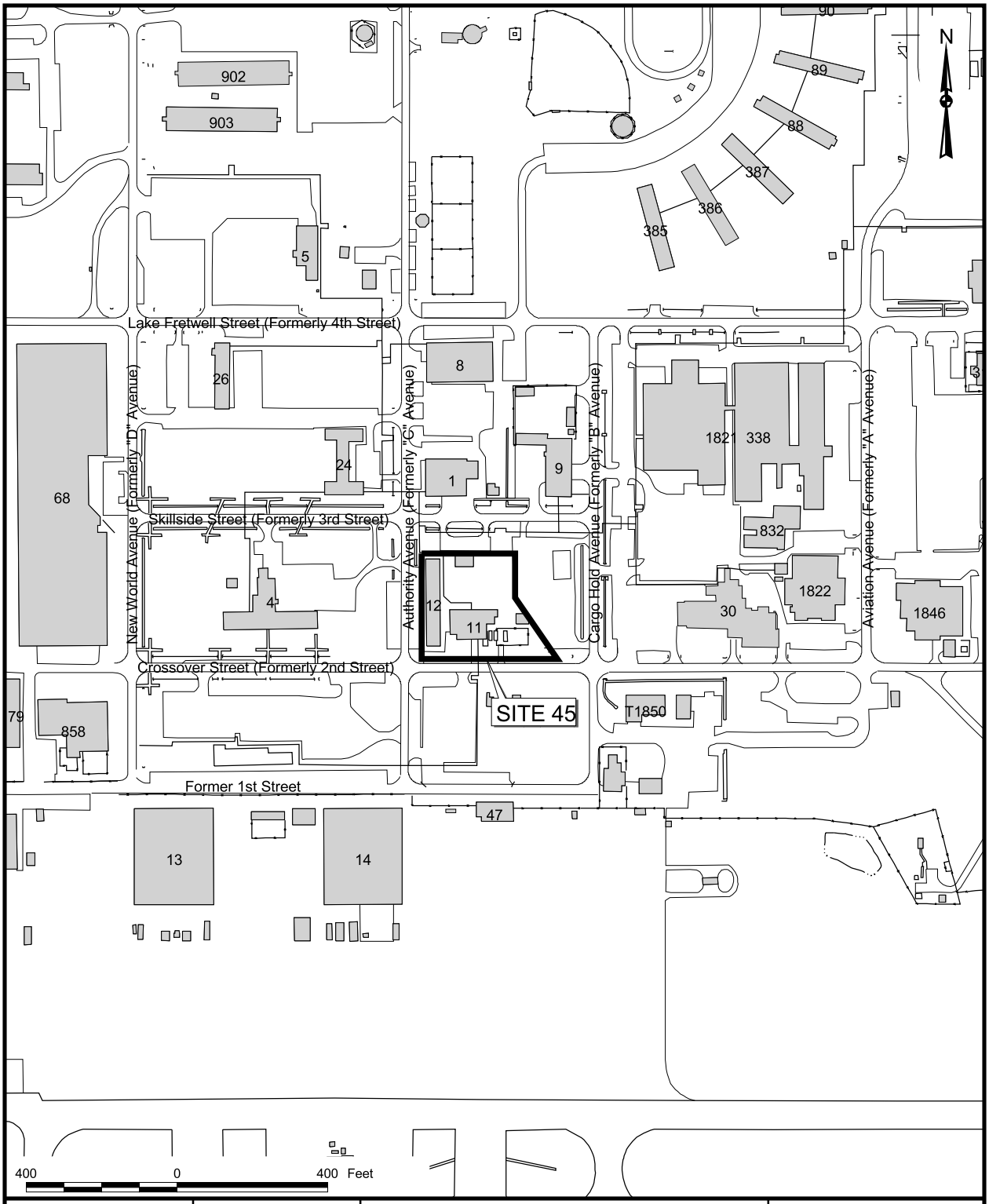
The site is primarily unpaved and covers an area of approximately 2 acres. The south border is Crossover Street, the west border is Authority Avenue, the north border is Skillside Street (formerly Third Street), and the east border is a parking lot. There are also parking lots adjacent to the buildings along Crossover Street, Skillside Street, and Authority Avenue. The base railroad tracks passed through the east side of the site, next to the current parking lot. These tracks were removed in 1986.

Building 11 was the Steam Generating Plant and includes a large room for three boilers, and several smaller rooms for office space, workshops, and rest rooms. The building was constructed in 1941. Building 2 is an administrative office and was constructed in 1985. Building 7 was used to store flammable and hazardous materials used for operations in Building 11. This building is divided into four



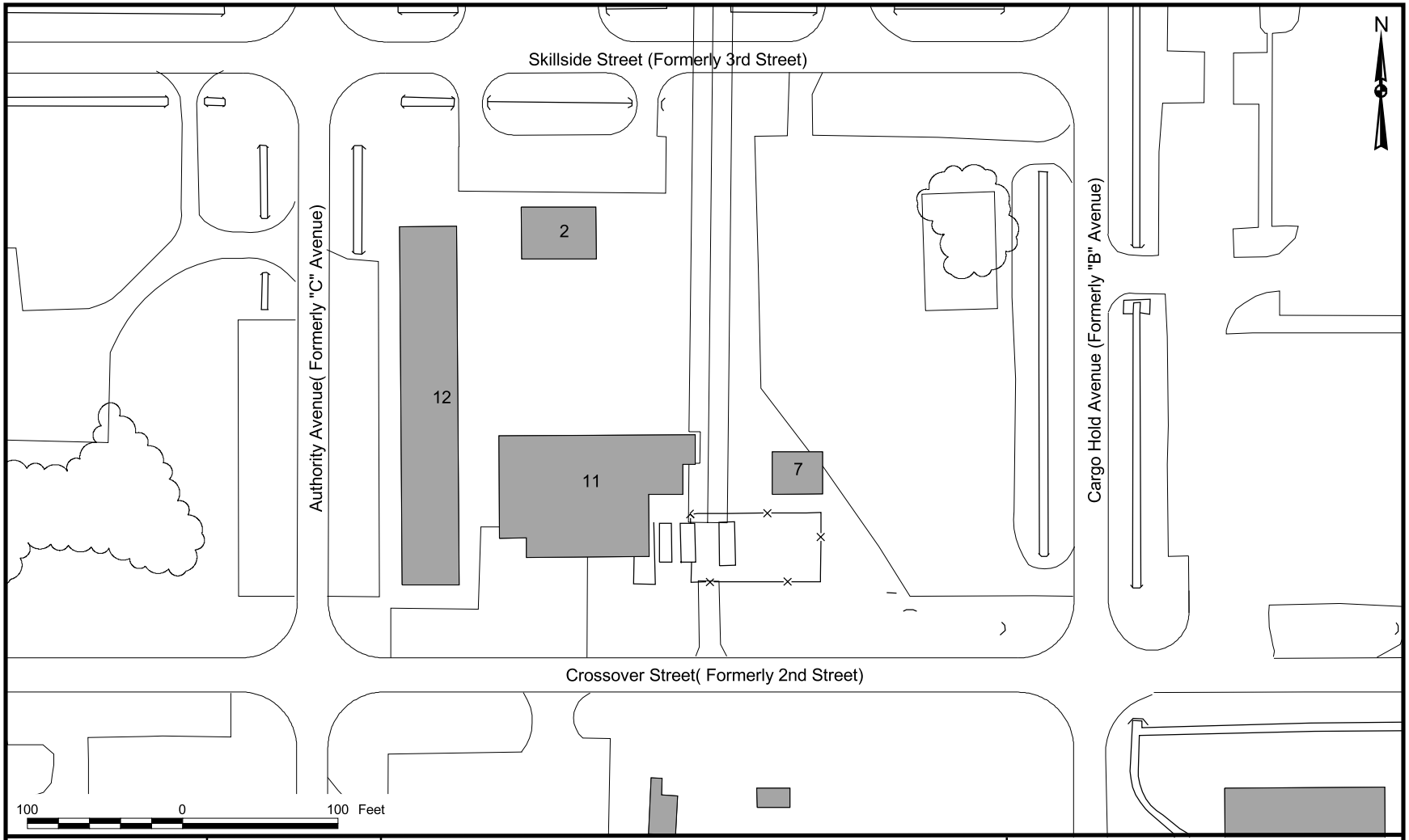
DRAWN BY MJJ	DATE 30Jun00	GENERAL LOCATION MAP SITE 45 REMEDIAL INVESTIGATION REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 / REV 1

P:\GIS\NAS_CecilField\PSC45_RI_Rev1.apr 14May01 MJJ Site Location Map Layout



DRAWN BY MJJ	DATE 08May00	SITE VICINITY MAP SITE 45 REMEDIAL INVESTIGATION REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-2 / REV 1

P:\GIS\NAS_CecilField\PSC45_RI_Rev1.apr 15May01 MJJ Facility Location Layout



DRAWN BY MJJ	DATE 30Jun00	GENERAL ARRANGEMENT SITE 45 REMEDIAL INVESTIGATION REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-3 / REV 1

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rooms, three for storage and one for electrical power. The building was constructed in 1989. Building 12 is the Operations Training Building and includes offices and classrooms for training. The building was built in 1941 as a utility building and hospital. In 1943, the building was converted to a headquarters administrative facility. In 1989, the building was converted to Operations Training (ABB-ES, 1994).

Soil contaminated with polynuclear aromatic hydrocarbons (PAHs), total recoverable petroleum hydrocarbon (TRPH), arsenic, mercury, and vanadium was delineated during earlier investigations. The contaminated soil was excavated to industrial levels and disposed off-site (TtNUS, 2000b; CH_2MHill, 2001). Groundwater contaminated by lead and vanadium was also identified in earlier studies, and further investigated during the RI (TtNUS, 2000c).

The name of the site has been changed over the course of the investigations. For the Environmental Baseline Study investigation, the site was designated as Facility 11. When it was determined that soil contamination was over a large area, the area was re-designated Potential Source of Contamination (PSC) 45 in January 1999. When the presence of groundwater contamination was confirmed, the area was designated as Installation Restoration (IR) Site 45, in February 2000.

1.1.2 Site Geology and Hydrogeology

Shallow soil to a depth of 6 feet (ft) below ground surface (bgs) was composed of approximately 91 percent fine sand and approximately 9 percent silt and clay, with a United Soil Classification System (USCS) classification of SW-SM. Deeper soil to a depth of 37 ft bgs was composed of approximately 98 percent fine sand and 2 percent silt and clay, with a USCS classification of SW. Specific gravity of the soil ranges from 2.58 to 2.63 and porosity ranged from 31.8 to 46.3 percent.

Three main hydrogeologic units underlie the site. These units, in ascending order, are the Floridan aquifer system, the intermediate aquifer system or confining unit, and the surficial aquifer. This FS is only concerned with the surficial aquifer.

Depth to groundwater at Site 45, as measured in April 2000, ranged from approximately 7 to 9 ft bgs. The surficial aquifer system in which the wells are installed is approximately 90 to 100 ft thick at NAS Cecil Field, although wells at Site 45 monitor only the shallow and intermediate zones to depths of 15 and 40 ft bgs, respectively.

Based on the water level data, groundwater flows to the southeast across the site. This direction of flow is consistent with nearby sites, such as Sites 36 and 37. The groundwater gradient is approximately 0.003, similar to the gradients measured at Sites 36 and 37 (0.001 to 0.007).

The velocity of groundwater flow can be calculated from a modified form of Darcy's equation:

$$Vh = Kh \times i/ne$$

Where,

Vh is horizontal velocity, ft/day

Kh is horizontal hydraulic conductivity, ft/day

i is hydraulic gradient, dimensionless

ne is effective porosity, dimensionless (assumed at 0.15 for fine sands)

Because the contamination is limited to the shallow zone of the surficial aquifer, groundwater velocity was only evaluated in that zone. The Kh value used was the average of the values derived from the specific capacity (SPECAP) test data for wells CEF-P45-4S and CEF-P45-5S.

Kh = 3.8 ft/day
i = 0.003
ne = 0.15.

The resulting Vh is 0.08 ft/day or 28 ft/year.

1.1.3 Site History

Since its construction, Building 11 has been used for steam generation for the entire base. Building 7 has always stored chemicals used in Building 11. The adjacent buildings, Buildings 2 and 12 have always been used for administrative functions. The three aboveground storage tanks provided fuel to the boilers, and an UST provided fuel to Building 11 for emergency generator (ABB-ES, 1994). Following NAS Cecil Field closure in September 1999 and transfer of the base to civilian ownership, the Building 11 steam generating facility has been deactivated.

1.1.4 Site Investigations

The following investigations and studies have been conducted in and around Site 45:

- November 1995 through February 1996 – Phase II investigation [Base Realignment and Closure (BRAC) program] of Building 7. One monitoring well was installed and sampled and one soil sample was collected. Samples were analyzed for target compound list (TCL) volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), and Target Analyte List (TAL) inorganic compounds (ABB-ES, 1997).

- November 1995 through September 1998 – Phase II investigation (BRAC program) of Building 11. One monitoring well was installed and sampled and four soil samples were collected. Samples were analyzed for TCL volatile organic compounds, semi volatile organic compounds, pesticides and PCBs, and TAL inorganics. An additional seven surface soil samples and 2 subsurface soil samples were collected and analyzed for PAHs (HLA, 1999c).

- January 1997 through August 1997 – Confirmatory sampling investigation for UST 11A. Five soil borings were installed and samples were collected for headspace analysis. One monitoring well was installed and one groundwater sample was analyzed for the Florida Department of Environmental Protection (FDEP) Kerosene Analytical Group (KAG) parameters (HLA, 1998b).

- February 1997 through October 1998 – Confirmatory sampling investigation and site assessment investigation for above ground storage tanks 11B, 11C, and 11D. Six soil borings for headspace analysis are advanced. One monitoring well was installed and one groundwater sample and one subsurface soil sample were analyzed for the FDEP KAG parameters (HLA 1998a, 1999a, and 1999b).

- June 1998 through March 2000 – Investigation of PSC 45. Samples were collected to delineate soil and groundwater contamination. Seventy-six surface soil samples and eleven subsurface soil samples were collected. Five new monitoring wells were installed and sampled, and three existing monitoring wells were sampled. Analyses were limited to the contaminants that had been detected in previous investigations. Typically, samples were analyzed for TRPH, PAHs, arsenic, lead, mercury, and vanadium. The results were used to delineate the soil contamination for excavation and disposal. The groundwater investigation identified four wells with vanadium and two wells with lead at concentrations greater than the FDEP criteria (TtNUS, 2000a).

- April through March 2000 – Site 45 RI. Samples were collected to further delineate lead and vanadium contamination of groundwater. Seven new monitoring wells were installed and sampled and five existing monitoring wells were sampled (TtNUS, 2000b). Groundwater samples were only analyzed for lead and vanadium. In addition, SPECAP tests were performed on two monitoring wells to determine site-specific hydrogeological conditions.

- August 2000 – Approximately 363 tons of soil contaminated with arsenic, vanadium, and benzo-a-pyrene in excess of their FDEP Soil Cleanup Target Levels (SCTLs) for industrial land use were excavated and disposed offsite (CH_2M Hill, 2001).

- March 2001 - One post-RI round of groundwater samples was collected and analyzed from six existing monitoring wells to check for potential vanadium attenuation. Samples were analyzed for natural attenuation parameters [alkalinity, chloride, ferrous iron, dissolved oxygen (DO), hydrogen sulfide, nitrate, nitrite, orthophosphate, oxidation/reduction potential (ORP), sulfate], general water quality parameters [pH, specific conductance, temperature, total organic carbon (TOC), turbidity] and selected total and dissolved metals (aluminum, calcium, iron, manganese, potassium, sodium, vanadium).

1.1.5 Summary of Investigations Findings

1.1.5.1 Nature and Extent of Soil Contamination

During the RI, carcinogenic PAHs (cPAHs), TRPH, arsenic, and mercury were detected in soil at concentrations in excess of the FDEP SCTLs for direct industrial and residential exposure. Vanadium was also detected in soil but at concentrations below the SCTL for direct industrial exposure. The presence of these chemicals in the soil is probably due to emissions fall-out from the combustion of fossil fuel for the generation of steam. A statistical evaluation was conducted to determine the areas of soil requiring removal to achieve a site-wide 95-percent upper confidence limit (UCL) that is below the SCTLs for direct industrial exposure. The results of this statistical evaluation are presented in the Action Memorandum for PSC 45 (TtNUS, 2000b).

A removal action was conducted in August 2000 (CH_2M Hill, 2001). During this removal action approximately 363 tons of soil were excavated and disposed offsite so that the 95-percent UCL of the residual concentrations of cPAHs, TRPH, arsenic, and mercury in soil is equal to or less than the SCTL for direct industrial exposure.

Because benzo(a)pyrene was the principal cPAH detected in the Site 45 soil, the BCT agreed that cPAHs detected in the soil of that site should be regarded as a family of compounds and that their concentrations should be expressed in terms of benzo(a)pyrene equivalents (BaPEq). For a given soil sample, a total BaPEq concentration was derived using detected concentrations of individual cPAHs and toxicity equivalent factors [United States Environmental Protection Agency (USEPA), 1995]. If a cPAH was not detected in a particular sample, a concentration of one-half of the analytical detection limit for that cPAH was used to compute the total BaPEq concentration of that sample.

Table 1-1 presents a summary of soil analytical data, including minimum and maximum detected concentrations, arithmetic means of detected concentration and 95-percent UCL concentrations for BaPEq, TRPH, arsenic, mercury, and vanadium detected in the Site 45 soil following the removal action. Table 1-1 also compares this analytical data to the FDEP SCTLs for direct industrial exposure, direct

TABLE 1-1

SUMMARY OF POST-REMOVAL ACTION SOIL ANALYTICAL DATA
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Analyte	Unit	Minimum Detected Concentration	Maximum Concentration	Mean	UCL	FDEP Direct Exposure Industrial[1]	FDEP Direct Exposure Residential[1]	FDEP Leachability[1]	IBDS
BaPEq	µg/kg	4	2,478	247	258	500	100	8,000	NA
Arsenic	mg/kg	0.1	9.6	1.9	2.0	3.7	0.8	29	2.04
Mercury	mg/kg	0.02	0.07	0.05	0.05	8.7	3.4	2.1	0.16
Vanadium	mg/kg	1.8	49	11	12	7,400	15	980	6.3
TRPH	mg/kg	10	439	79	83	2,500	340	340	NA

NOTES:

1. FDEP Draft Soil Cleanup Target Levels (FDEP, 1999a).

BaPEq: Benzo(a)pyrene equivalent
IBDS NAS Cecil Field site-specific Inorganic Background Data Set (HLA, 1998c)
µg/kg micrograms per kilogram
mg/kg milligrams per kilogram
Mean arithmetic mean of analytical data
NA not available
TRPH: total recoverable petroleum hydrocarbon
UCL 95-percent upper confidence limit

residential exposure, and leachability to groundwater; and to the NAS Cecil Field site-specific IBDS. As can be seen from Table 1-1, the site-wide 95-percent UCL concentrations of BaPEq, and TRPH, remaining in soil following the removal action still considerably exceed the SCTLs for direct residential exposure. Table 1-1 also shows that concentrations of arsenic remaining in soil exceed the NAS Cecil Field site-specific IBDS. Exceedances of the FDEP SCTLs for direct residential exposure are illustrated on Figure 1-4.

1.1.5.2 Nature and Extent of Groundwater Contamination

Lead and vanadium were detected in groundwater at concentrations greater than their respective FDEP Groundwater Cleanup Target Levels (GCTLs) of 15 and 49 micrograms per liter (µg/L) (FDEP, 1999a). Tables 1-2, 1-3, and 1-4 present a summary of lead and vanadium detections in groundwater during the pre-RI, RI, and post-RI samplings, respectively.

As shown on Table 1-2, lead was detected slightly in excess of its GCTL at two locations during the pre-RI samplings (16.8 µg/L at CEF-P45-01S and 17.3 µg/L at CEF-P45-04S). However, as shown on Table 1-3, neither of these exceedances was confirmed by the results of the RI samplings. Lead was in fact detected in excess of its GCTL at one location (34.6 µg/L at CEF-P45-08S) during the first round of RI sampling but this exceedance was not confirmed by the results of the second round.

As shown on Table 1-1, vanadium was detected significantly in excess of its GCTL at several locations during the pre-RI samplings. The maximum detected concentration of vanadium was 740 µg/L in well CEF-011-01Sa. As shown on Tables 1-3 and 1-4, these exceedances were confirmed by the results of the RI samplings with a maximum detected vanadium concentration of 240 µg/L and 284 µg/L in well CEF-007-01Sa during the RI and post-RI samplings, respectively. Monitoring wells were used to delineate the horizontal and vertical extent of the vanadium plume. This plume, as defined by the GCTL for vanadium, extends approximately 260 ft in length by 110 ft in width, as illustrated on Figure 1-5.

Vanadium was detected at concentration in excess of its GCTL in the samples collected only in monitoring wells screened in the shallow zone of the surficial aquifer, at approximately 15 ft bgs. Vanadium were also detected at concentrations below GCTL in samples collected from the monitoring well (CEF-P45-10I) screened in the intermediate zone of the surficial aquifer (35-40 ft bgs).

The source of the vanadium detected in the groundwater appears to be from the soil in the unsaturated zone. Vanadium was detected in soil samples but only at concentrations less than the FDEP SCTLs for leachability to groundwater. The origin of this metal is assumed to be from the combustion of fuel in the Building 11 steam boilers.

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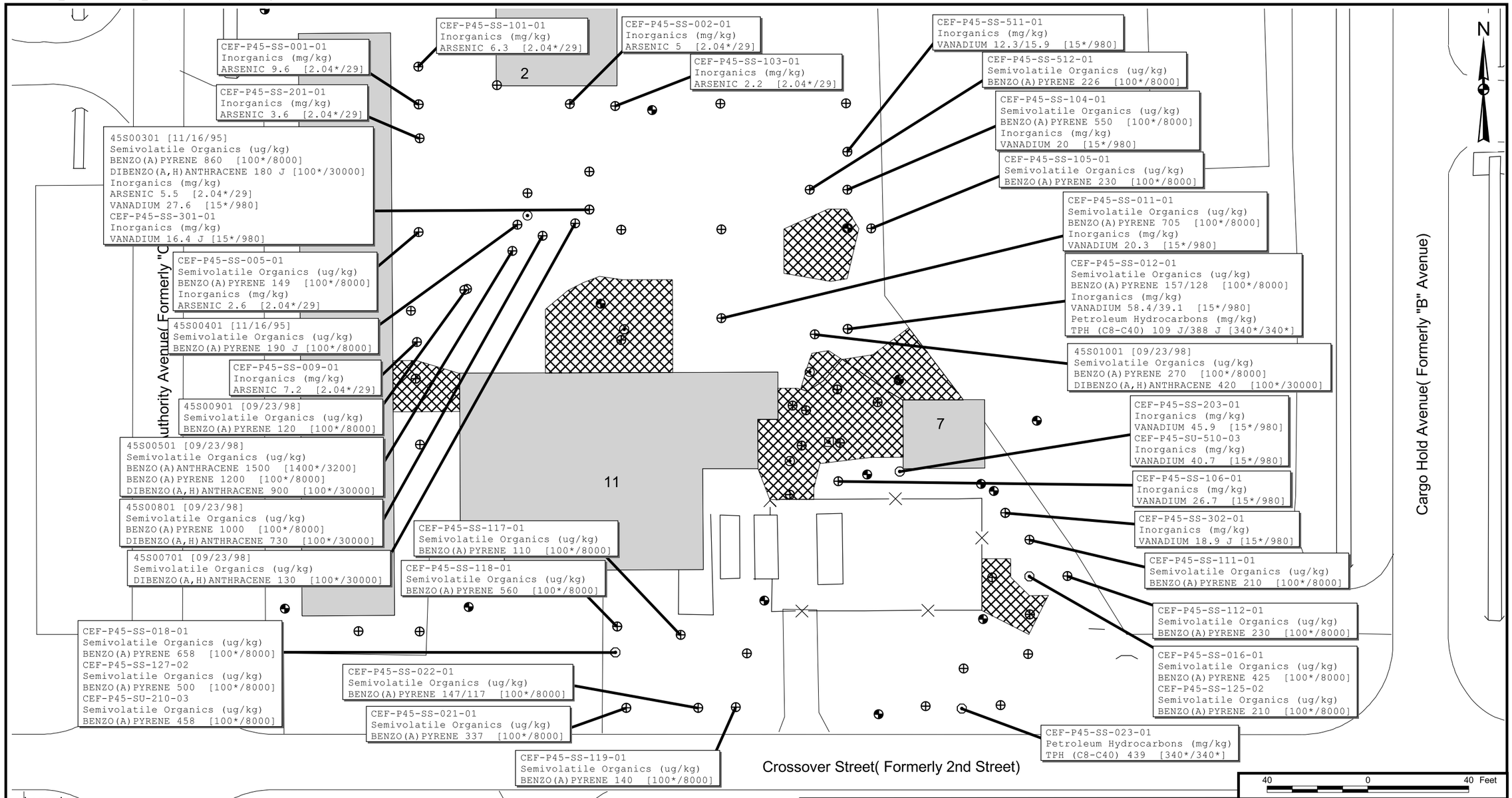


Legend

- Monitoring Well
- Surface Soil Sample
- Surface and Subsurface Soil Sample
- Subsurface Soil Sample
- Buildings
- Excavation Area

CEF-P46-SS-001 — Sample ID
Fraction (ug/kg) — FDEP Residential SCTL / FDEP Leachability SCTL
PARAMETER 500 [100/100] — Detection Concentration / Parameter

DRAWN BY MJJ	DATE 15May00	SOIL CONCENTRATIONS GREATER THAN RESIDENTIAL SCTLs (POST-EXCAVATION) OU 11, SITE 45 FEASIBILITY STUDY REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NO. 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-4 / REV. 0

TABLE 1-2

SUMMARY OF GROUNDWATER LEAD AND VANADIUM DETECTIONS
PRE-RI SAMPLINGS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Chemical	**Detected Concentrations** (µg/L, total / filtered)							**FDEP GCTL[1]** (µg/L)	**USEPA MCL[2]** (µg/L)	**IBDS[3]** (µg/L)
	CEF-007-01Sa	CEF-011-01Sa	CEF-P45-01S	CEF-P45-02S	CEF-P45-03S	CEF-P45-04S	CEF-P45-05S			
02/96										
Lead	2 U / NA	9.7 / NA	NS	NS	NS	NS	NS	15	15	5.35
Vanadium	**147** / NA	**195** / NA	NS	NS	NS	NS	NS	49	NC	20.2
10/98										
Lead	NS	NA / NA	NS	NS	NS	NS	NS	15	15	5.35
Vanadium	NS	**740** / **720**	NS	NS	NS	NS	NS	49	NC	20.2
07/99										
Lead	3.9 U / 3.2 U	NS	5 U / **16.8**	8.4 2.3 U	5.7 U / 1.8 U	NS	NS	15	15	5.35
Vanadium	**695** / **744**	NS	31.4 / 30	**280** / **235**	33 / **250**	NS	NS	49	NC	20.2
09/99										
Lead	NS	NS	NS	NS	NS	**17.3** / NA	2.5 U / NA	15	15	5.35
Vanadium	NS	NS	NS	NS	NS	**54.2** / NA	4.1 / NA	49	NC	20.2

NOTES

Bolded values indicate an exceedance of the FDEP GCTL

(1) Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level (GCTL) (FDEP, 1999a)
(2) United States Environmental Protection Agency (USEPA) Maximum Contaminant Levels
(3) NAS Cecil Field site-specific Inorganic Background Data Base (IDBS) (HLA, 1998c)
NA not analyzed
NC no criterion
NS not sampled
U not detected at the indicated detection limit

TABLE 1-3

SUMMARY OF GROUNDWATER LEAD AND VANADIUM DETECTIONS
RI SAMPLINGS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Sampling Location	Chemical	Concentrations (µg/L, total/filtered)		FDEP GCTL[1] (µg/L)	USEPA MCL[2] (µg/L)	IBDS[3] (µg/L)
		04/00	08/00			
CEF-007-01Sa	Lead	1.6U / 1.6U	NS	15	15	5.35
	Vanadium	**240** / **233**	NS	49	NC	20.2
CEF-P45-01S	Lead	3.6U / 1.6U	NS	15	15	5.35
	Vanadium	13.3 / 5.5	NS	49	NC	20.2
CEF-P45-02S	Lead	1.6U / 1.6U	NS	15	15	5.35
	Vanadium	**74.9** / **85**	NS	49	NC	20.2
CEF-P45-03S	Lead	5.8U / 1.6U	NS	15	15	5.35
	Vanadium	**49** / 40.4	NS	49	NC	20.2
CEF-P45-04S	Lead	5.4U / 3.1U	NS	15	15	5.35
	Vanadium	**68.2** / **53.6**	NS	49	NC	20.2
CEF-P45-06S	Lead	1.6U / 1.6U	NS	15	15	5.35
	Vanadium	3 / 1.7	NS	49	NC	20.2
CEF-P45-07S	Lead	1.8U / 1.7U	NS	15	15	5.35
	Vanadium	5 / 3.6	NS	49	NC	20.2
CEF-P45-08S	Lead	**34.6** / 10.2	5.3 /2.9	15	15	5.35
	Vanadium	5.4 / 3.7	NA	49	NC	20.2
CEF-P45-09S	Lead	1.6U / 1.6U	NS	15	15	5.35
	Vanadium	0.7U / 0.7U	NS	49	NC	20.2
CEF-P45-10I	Lead	12.6 / 1.6U	NS	15	15	5.35
	Vanadium	26.5 / 3.9	NS	49	NC	20.2
CEF-P45-11S	Lead	1.6 / 1.6U	NS	15	15	5.35
	Vanadium	4.3 / 3.9	NS	49	NC	20.2
CEF-P45-12S	Lead	1.6U / 1.6U	NS	15	15	5.35
	Vanadium	2 / 2.1	NS	49	NC	20.2

NOTES:
Bolded values indicate an exceedance of the FDEP GCTL.

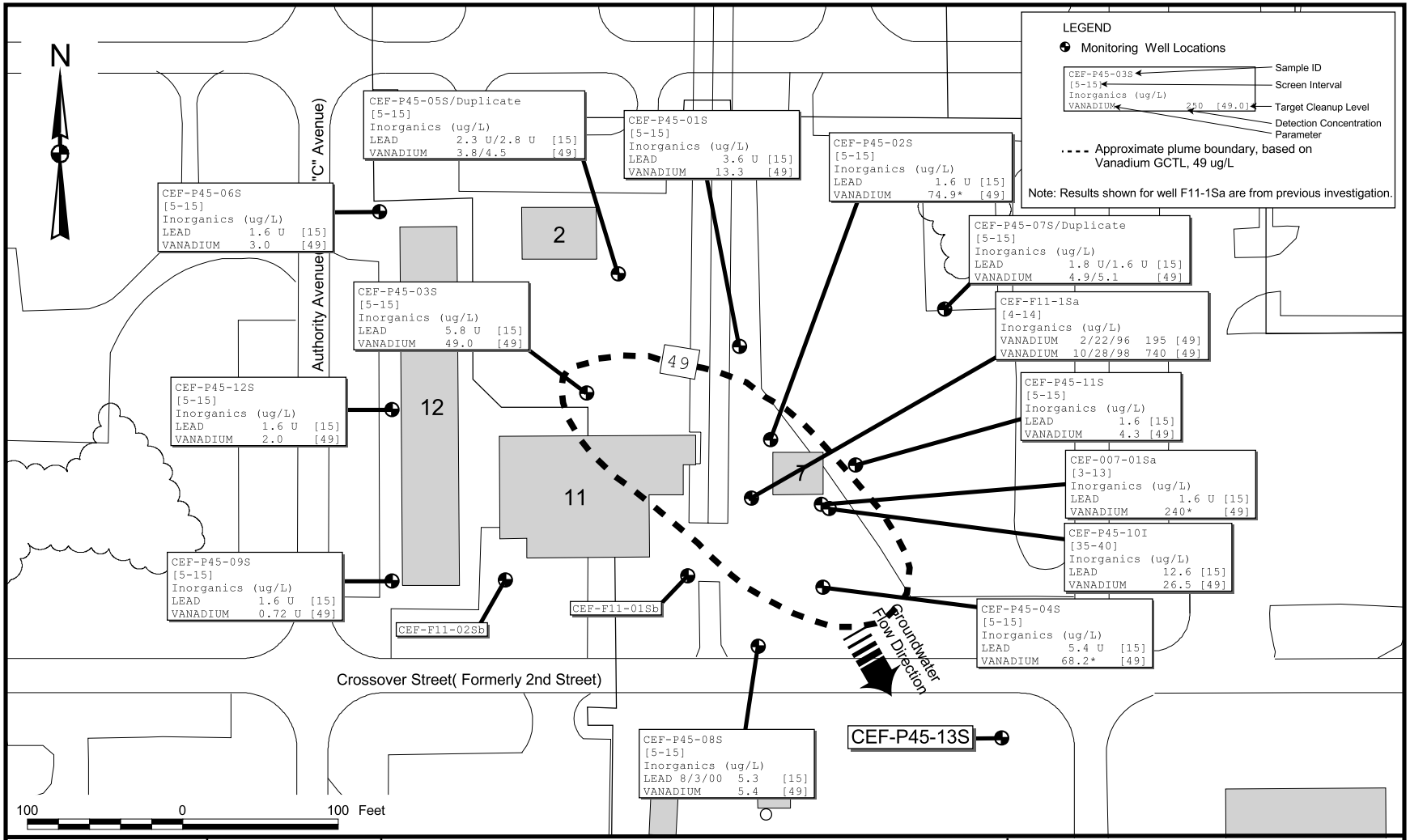
(1) Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level (GCTL) (FDEP, 1999a)
(2) United States Environmental Protection Agency (USEPA) Maximum Contaminant Levels
(3) NAS Cecil Field site-specific Inorganic Background Data Base (IDBS) (HLA, 1998c)
NA not analyzed
NC no criterion
NS not sampled
U not detected at the indicated detection limit

TABLE 1-4

SUMMARY OF GROUNDWATER ANALYTICAL DATA
POST-RI SAMPLING
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Parameter	Units	Monitoring Well Locations					
		P45-2S	P45-3S	P45-4S	P45-7S	F11-1Sa	007-1Sa
Alkalinity	mg/L	135	17.2	25.8	60.1	127	67.6
Alkalinity, field	mg/L	265	48	134	117	5110	169
Chloride	mg/L	4.5	6	35.5	8	165	5
Ferrous iron, field	mg/L	0.02	0.14	0.36	0.39	0.86	0.01
Dissolved oxygen, field	mg/L	3	2.5	3	1	NM*	6
Dissolved oxygen, Horiba	mg/L	3.7	1.2	1.9	0.7	2.3	6.4
Dissolved sulfide	mg/L	<2.0	<2.0	3.7	3.3	<2.0	<2.0
Hydrogen sulfide, field	mg/L	0	0	5	5	1	0
Sulfide, field	mg/L	0.01	0.13	0.78	0.29	0.67	0.04
Nitrate	mg/L	1.6	1.4	<0.10	0.19	0.28	2.4
Nitrite	mg/L	0.18	<0.010	<0.010	<0.010	<0.050	<0.010
Orthophosphate	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
pH, field	St. units	6.3	6.2	5.4	6.0	6.2	6.7
ORP, field	mV	117	100	-78	-162	-169	177
Specific conductance, field	mS/cm	0.519	0.110	0.301	0.334	1.08	0.298
Sulfate	mg/L	41.7	32.6	<10	32.4	72.3	24.4
Temperature	^{o}C	21.1	19.1	22.7	22.5	19.0	19.7
TOC	mg/L	13.9	11.4	214	51.2	285	18.9
Turbidity	NTU	6.2	55	78	62.7	20.7	11.7
Turbidity, field	NTU	4.5	62	140	72	21	0
Total Aluminum	ug/L	281	3280	14500	1670	8760	545
Filtered Aluminum	ug/L	280	1140	11100	1130	7510	233
Total Calcium	ug/L	92600	11600	8030	42600	32500	58500
Filtered Calcium	ug/L	83400	10900	8310	39000	31000	57800
Total Iron	ug/L	20.9	220	392	411	840	9.4
Filtered Iron	ug/L	30	96.3	377	331	691	9.02 U
Total Magnesium	ug/L	4720	1020	314	2010	1780	664
Filtered Magnesium	ug/L	4210	1010	387	1850	1720	653
Total Manganese	ug/L	1	0.32	1.8	19.4	30.4	.26 U
Filtered Manganese	ug/L	0.79	0.87	5.2	17.6	28.4	.26 U
Total Potassium	ug/L	4520	889	2380	6660	1920	1500
Filtered Potassium	ug/L	4240	892	2740	5940	1910	1590
Total Sodium	ug/L	20500	7540	62800	5530	203000	2480
Filtered Sodium	ug/L	30300	7290	56000	5090	197000	2600
Total Vanadium	ug/L	211	66	85	5.9	281	284
Filtered Vanadium	ug/L	221	60.9	78.3	5	259	262

U = Not detected at or above method detection limit (associated value).
J = Estimated concentration.
NA = Not analyzed.
ORP = Oxidation-reduction potential
mS/Cm = microSiemens/centimeter
NTU = Nephelometric turbidity units
TOC = Total organic carbon
^{o}C = degrees Celcius
NM* = Not measured. Color interference.
Well P45-2S was duplicated and the greater of the two values is shown.



DRAWN BY MJJ	DATE 02Oct00	GROUNDWATER RESULTS - RI OU 11, SITE 45 FEASIBILITY STUDY REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-5 / REV 0

P:\GIS\NAS_CecilField\PSC45_FS.apr 04Jun01 MJJ 1-5 Layout

1.1.5.3 Contaminant Fate and Transport

Vanadium was detected in groundwater at concentrations greater than the FDEP criterion. Vanadium was also detected in the soil. These findings are consistent with expectations in that this element is relatively mobile. Failure to detect PAHs and TRPH in groundwater is consistent with expectations in that these compounds are relatively immobile in the soil.

1.1.5.4 Human Health Risk Assessment

The Preliminary Risk Assessment (PRE) performed as part of the RI indicated that, although the concentrations of vanadium detected in groundwater were above the FDEP GCTL, exposure to groundwater would not likely result in adverse health effects because detected concentrations did not exceed USEPA Region 9 risk-based criteria (USEPA, 2001) and because no elevated concentrations of vanadium remain in soil following the removal action.

The 95-percent UCL of the concentrations of the soil remaining at the site is less than the FDEP SCTLs for direct industrial exposure.

1.1.5.5 Ecological Risk Assessment

The ecological risk assessment performed as part of the RI established that Site 45 consists primarily of buildings and parking lots that provide an ecological habitat of marginal quality and of little use to terrestrial wildlife. Therefore, the RI concluded that Site 45 does not present a significant ecological risk.

1.2 DOCUMENT ORGANIZATION

This FS Report has been organized with the intent of meeting the general format requirements specified in the RI/FS Guidance Document (USEPA, 1988). This report features the following five section:

- Section 1.0, Introduction, summarizes the purpose of the report, provides site background information, summarizes findings of the RI, and provides the report outline.

- Section 2.0, Remedial Action Objectives and General Response Actions, presents the RAOs, identifies Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) criteria, develops groundwater PRGs and associated General Response Actions (GRAs), and provides an estimate of the volume of contaminated soil and groundwater to be remediated.

- Section 3.0, Screening of Remediation Technologies and Process Options, provides a two-tiered screening of potentially applicable soil and groundwater remediation technologies and identifies the technologies that will be assembled into remedial alternatives.

- Section 4.0, Assembly and Detailed Analysis of Remedial Alternatives, assembles the remedial technologies retained from the Section 3.0 screening process into multiple soil and groundwater remedial alternatives, describes these alternatives, and performs a detailed analysis of these alternatives in accordance to seven Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria.

- Section 5.0, Comparative Analysis of Remedial Alternatives, compares the soil and groundwater remedial alternatives on a criterion-by-criterion basis, for each of the seven CERCLA analysis criteria used in Section 4.

2.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

This section develops RAOs and derives PRGs for the contaminated media. The regulatory requirements and guidances (e.g., ARARs) that may potentially govern remedial activities are presented in this section. In addition, this section presents the chemicals of concern (COCs) identified in Section 1.0 and the conceptual pathways through which these chemicals may affect human health, and thus derives the environmental media of concern. The PRGs for the contaminated media are developed in this section, and GRAs that may be suitable to achieve the PRGs are presented. Finally, this section presents an estimate of the volumes of contaminated media.

2.1 REMEDIAL ACTION OBJECTIVES

The purpose of this section is to develop RAOs for Site 45 at NAS Cecil Field, Jacksonville, Florida. Development of RAOs is an important step in the FS process. The RAOs are medium-specific goals that define the objective of conducting remedial actions to protect human health and the environment. The RAOs specify the COCs, potential exposure routes and receptors, and an acceptable range contaminant level (i.e., PRGs) for the site.

The development of PRGs takes into consideration ARARs and TBCs. Section 2.1.2 identifies the ARARs and TBCs, Section 2.1.3 identifies the media of concern, and Section 2.1.4 identifies the COCs for remediation.

2.1.1 Statement of Remedial Action Objectives

Site-specific RAOs specify COCs, media of interest, exposure pathways, and cleanup goals or acceptable contaminant concentrations. RAOs may be developed to permit consideration of a range of treatment and containment alternatives. This FS addresses soil and groundwater contamination at Site 45. To protect the public from potential current and future health risks, as well as to protect the environment, the following RAOs have been developed:

- Prevent unacceptable risk from exposure to soil with concentrations of BaPEq and TRPH in excess of the FDEP residential SCTLs and concentrations of arsenic in excess of the IBDS.

- Prevent unacceptable risk from ingestion of groundwater with concentrations of vanadium in excess of the FDEP GCTL.

2.1.2 Applicable or Relevant and Appropriate Requirements and To Be Considered Criteria

ARARs consist of the following:

- Any standard, requirement, criterion, or limitation under Federal environmental law.
- Any promulgated standard, requirement, criteria, or limitation under a state environmental or facility-siting law that is more stringent than the associated Federal standard, requirement, criterion, or limitation.

TBCs are nonpromulgated, nonenforceable guidelines or criteria that may be useful for developing a remedial action or are necessary for determining what is protective to human health and/or the environment. Examples of TBCs include United States Environmental Protection Agency (USEPA) Drinking Water Health Advisories, Reference Doses (RfDs) and Cancer Slope Factors (CSFs).

One of the primary concerns during the development of remedial action alternatives for hazardous waste sites under CERCLA is the degree of human health and environmental protection offered by a given remedy. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent Federal and state environmental requirements.

2.1.2.1 Definitions

The definitions of ARARs are given below:

- Applicable Requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law, while not "applicable" to a hazardous substance, pollutant, contaminant, or remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

- TBCs are a category created by the USEPA that includes non-promulgated criteria, advisories, and guidance issued by Federal or state government that are not legally binding and do not have the

status of potential ARARs. However, pertinent TBCs will be considered along with the ARARs in determining the necessary level of cleanup or technology requirements.

Under CERCLA Section 121(d)(4), the USEPA may waive compliance with an ARAR if one of the following conditions can be demonstrated:

- The remedial action selected is only part of a total remedial action that will attain the ARAR level or standard of control upon completion;

- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;

- Compliance with the requirement is technically impracticable from an engineering perspective;

- The remedial action selected will attain a standard of performance that is equivalent to that required by the ARAR through the use of another method or approach;

- With respect to a state requirement, the state has not consistently applied the ARAR in similar circumstances at other remedial actions within the state; or

- Compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of Superfund money for response at other facilities (fund-balancing). This condition only applies to Superfund-financed actions.

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) has identified three categories of ARARs [40 CFR Section 300.400 (g)]:

- Chemical-Specific: Health/risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples include Maximum Contaminant Levels (MCLs) and Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC).

- Location-Specific: Restrict actions or contaminant concentrations in certain environmentally sensitive areas. Examples of these areas regulated under various Federal laws include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

- Action-Specific: Technology- or activity-based requirements, limitations on actions, or conditions involving special substances. Examples of action-specific ARARs include wastewater discharge standards.

The following section discusses contaminant- and location-specific ARARs and TBCs. Action-specific ARARs and TBCs are presented in Section 2.3 along with the discussion of GRAs.

2.1.2.2 Chemical-Specific ARARs and TBCs

This section presents a summary of Federal and state chemical-specific ARARs and TBCs. These ARARs and TBCs provide some medium-specific guidance on "acceptable" or "permissible" concentrations of contaminants. Tables 2-1 and 2-2 present a list of Federal and State of Florida chemical-specific ARARs and TBCs for this FS.

2.1.2.3 Location-specific ARARs and TBCs

This section presents a summary of Federal and state location-specific ARARs and TBCs. These ARARs and TBCs place restrictions on concentrations of contaminants or the conduct of activities based upon the site's particular characteristics or location. Tables 2-3 and 2-4 present a list of Federal and State of Florida location-specific ARARs and TBCs for this FS.

2.1.3 Media of Concern

Based upon the discussion in Section 1.0 involving toxicity and risk assessment for both human and ecological receptors, the media of concern at Site 45 were determined to be soil and groundwater.

2.1.4 Chemicals of Concern for Remediation

2.1.4.1 Soil Chemicals of Concern

The RI HHRA identified several chemicals in the soil as a concern to human receptors. Post-Removal Action soil analytical data were compared to the FDEP SCTLs for direct residential exposure and leachability to groundwater (FDEP, 1999a).

BaPEq and TRPH were detected in soil above the FDEP SCTLs for direct residential exposure. Arsenic was detected in soil above the IBDS. These chemicals were therefore retained as COCs.

TABLE 2-1

FEDERAL CHEMICAL-SPECIFIC ARARs
OU11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Safe Drinking Water Act (SWDA) Regulations, Maximum Contaminant Levels (MCLs)	40 CFR Part 141	Relevant and Appropriate	Establishes enforceable standards for potable water for specific contaminants that have been determined to adversely affect human health.	Would be used as protective levels for groundwater or surface waters that are current or potential drinking water sources.
SDWA Regulations, National Secondary Drinking Water Standards (SMCLs)	40 CFR Part 143	TBC	Establishes welfare-based standards for public water systems for specific contaminants or water characteristics that may affect the aesthetic qualities of drinking water.	Would be used as protective levels for groundwater or surface waters that are current or potential drinking water sources.
USEPA Office of Drinking Water, Health Advisories		TBC	Health advisories are estimates of non-carcinogenic risk due to consumption of contaminated drinking water.	These advisories would be considered for contaminants in surface water and groundwater that is or could be used as a potable water source.
Cancer Slope Factors (CSFs)		TBC	CSFs are guidance value used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	CSFs would be considered for development of human health protection PRGs for soil and groundwater at this site.
Reference Doses (RfDs)		TBC	RfDs are guidance values used to evaluate the potential noncarcinogenic hazard caused by exposure to contaminants.	RfDs would be considered for development of human health protection PRGs for soil and groundwater at this site.

TABLE 2-2

STATE CHEMICAL-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Surface Water Quality Standards	FAC Chapter 62-302	Potentially Applicable	This rule distinguishes surface water into five classes based on designated uses and establishes ambient water quality standards (called Florida Water Quality Standards) for listed pollutants.	Because these standards are specifically tailored to Florida waters, they should be used to establish cleanup levels rather than the Federal AWQC.
Groundwater Classes, Standards and Exemptions	FAC Chapter 62-520	Applicable	This rule designates the groundwater of the state into five classes and establishes minimum "free from" criteria. This rule also specifies that Classes I & II must meet the primary and secondary drinking water standards listed in Chapter 62-550.	This rule would be used to establish PRGsfor groundwater that is a potential source of drinking water.
Drinking Water Criteria	FAC Chapter 62-550	TBC	This rule provides primary and secondary drinking water quality criteria.	This rule would be considered for the establishment of PRGs
Contaminant Cleanup Target Levels Rule	FAC Chapter 62-777	TBC	This rule provides guidance for soil, groundwater, and surface water cleanup levels that can be developed on a site-by-site basis.	This rule would be considered for the establishment of PRGs.

TABLE 2-3

FEDERAL LOCATION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Endangered Species Act Regulations	50 CFR Parts 81, 225, 402	Potentially Applicable	This act requires Federal agencies to act to avoid jeopardizing the continued existence of federally listed endangered or threatened species.	If a site investigation or remediation could potentially affect an endangered species, these regulations would apply.
Historic Sites Act Regulations	36 CFR Part 62	Potentially Applicable	Requires Federal agencies to consider to existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	The existence of Natural Landmarks would be identified prior to remedial activities onsite including remedial investigations
Fish and Wildlife Coordination Act Regulations	33 CFR Subsection 320.3	Potentially Applicable	Requires that the United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and related state agencies be consulted prior to structural modification of any body of water, including wetlands. If modifications must be conducted, the regulation requires that adequate protection be provided for fish and wildlife resources.	If a remedial alternative involves the alteration of a stream or wetland, these agencies would be consulted.
National Environmental Policy Act (NEPA) Regulations, Wetlands, Floodplains, etc.	40 CFR Subsection 6.302 [a]	Potentially Applicable	These regulations contain the procedures for complying with Executive Order 11990 on wetlands protection. Appendix A states that no remedial alternative adversely affect a wetland if another practicable alternative is available. If no alternative is available, impacts from implementing the chosen alternative must be mitigated.	If remedial action affects a wetland, these regulations would apply.

TABLE 2-3

FEDERAL LOCATION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
National Environmental Policy Act (NEPA) Regulations, Floodplain Management, Executive Order 11988	40 CFR Part 6, Appendix A	Potentially Applicable	Appendix A describes the policy for carrying out the Executive Order regarding floodplains. If no practicable alternative exists to performing cleanup in a floodplain, potential harm must be mitigated and actions taken to preserve the beneficial value of the floodplain.	If removal actions take place in a floodplain, alternatives would be considered that would reduce the risk of flood loss and restore and preserve the floodplain.
Fish and Wildlife Conservation Act	40 CFR Section 6.302	Potentially Applicable	Requires action to be taken to protect fish and wildlife from projects affecting streams or rivers.	USFWS officials would be consulted on how to minimize impacts of any remedial activities on any wildlife.

TABLE 2-4

STATE LOCATION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken

There are no State Location-Specific ARARs

2.1.4.2 Groundwater Chemical of Concern

The HHRA also identified one chemical in the groundwater as a concern to human receptors. Analytical groundwater data for the site were compared to the USEPA's current drinking water standards (USEPA, 1998), The FDEP drinking water criteria (FDEP, 1999b), the FDEP GCTLs (FDEP, 1999a), and the NAS Cecil Field site-specific Inorganic Background Data Set (IBDS) screening criteria (HLA, 1998c).

Vanadium, was detected in the groundwater above the FDEP GCTL and was therefore retained as a COC.

2.2 PRELIMINARY REMEDIATION GOALS

A PRG is the target concentration to which a COC must be reduced within a particular medium of concern to achieve one or more of the established RAOs. PRGs are developed to ensure that contaminant concentration levels left on site are protective of human and ecological receptors.

2.2.1 Soil PRGs

For Site 45, soil PRGs were established based on the following criteria:

- Protection of human health from direct exposure to contaminated soil
- Compliance with ARARs and TBCs to the extent practicable

Accordingly, the following soil PRGs were established:

COC	PRGs
BaPEq	100 µg/kg(1)
Arsenic	2.04 mg/kg(2)
TRPH	340 mg/kg

(1) FDEP SCTLs for direct residential exposure (FDEP, 1999a)
(2) NAS Cecil Field site-specific IBDS (HLA, 1998c)

2.2.2 Groundwater PRG

For Site 45, a groundwater PRG was determined for vanadium based on the following criteria:

- Protection of human health from exposure to contaminated groundwater
- Compliance with ARARs and TBCs to the extent practicable

Accordingly the vanadium PRG for groundwater at Site 45 was established as 49 µg/L, which is the FDEP GCTL for this chemical.

2.3 GENERAL RESPONSE ACTIONS (GRAs) AND ACTION-SPECIFIC ARARs

GRAs are broadly defined remedial approaches that may be used (by themselves or in combination with one or more of the others) to attain the RAO. Action-specific ARARs and TBCs are those regulations, criteria, and guidances that must be complied with or taken into consideration during remedial activities on site.

2.3.1 General Response Actions

GRAs describe categories of actions that could be implemented to satisfy or address a component of the RAOs for the site. Remedial action alternatives will then be composed using general response actions singly or in combination to meet the RAOs. The remedial action alternatives, composed of GRAs, will be capable of achieving the RAOs for each contaminated medium at the site.

The following GRAs will be considered for groundwater at Site 45:

- No Action,
- Limited Action (Natural Attenuation, Institutional Controls, Monitoring),
- Containment.
- Removal,
- In-Situ Treatment,
- Ex-Situ (On-Site) Treatment, and
- Disposal

2.3.2 Action-Specific ARARs

Action-specific ARARs and TBCs are technology- or activity-based regulatory requirements or guidance that would control or restrict remedial action. Tables 2-5 and 2-6 present a list of Federal and state action-specific ARARs and TBCs for this FS.

2.4 ESTIMATED VOLUMES OF CONTAMINATED MEDIA

For remedial action purposes, preliminary volumes of contaminated soil and groundwater were estimated based on the location of samples where COCs were detected in excess of PRGs.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Clean Water Act (CWA), National Pollution Discharge Elimination System (NPDES)	40 CFR Parts 122 through 125, and 131	Potentially Relevant and Appropriate	NPDES (National Pollution Discharge Elimination System) permits are required for any discharges to navigable waters. If remedial activities include such a discharge, the NPDES standards would be ARARs.	Any alternative which would discharge into any navigable water would require compliance with these regulations including treatment, if necessary.
Occupational Safety and Health Act (OSHA) Regulations, General Industry Standards	29 CFR Part 1910	Applicable	Requires establishment of programs to assure worker health and safety at hazardous waste sites, including employee training requirements.	These regulations would apply to all response activities.
OSHA Regulations, Occupational Health and Safety Regulations	29 CFR Part 1910, Subpart Z	Potentially Applicable	Establishes permissible exposure limits for workplace exposure to a specific listing of chemicals.	Standards are applicable for worker exposure to OSHA hazardous chemicals during remedial activities.
OSHA Regulations, Recordkeeping, Reporting, and Related Regulations	29 CFR Part 1904	Potentially Applicable	Provides recordkeeping and reporting requirements applicable to remedial activities.	These requirements apply to all site contractors and subcontractors and must be followed during all site work.
OSHA Regulations, Health and Safety Standards	29 CFR Part 1926	Potentially Applicable	Specifies the type of safety training, equipment, and procedures to be used during the site investigation and remediation.	All phases of the remedial response project would be executed in compliance with this regulation.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Resource Conservation and Recovery Act (RCRA) Regulations, Contingency Plan and Emergency Procedures	40 CFR 264, Subpart D	Potentially Relevant and Appropriate	Outlines requirements for emergency procedures to be followed in case of an emergency.	The administrative requirements established in this rule would be met for remedial actions involving the management of hazardous waste.
CWA Regulations, National Pretreatment Standards	40 CFR Part 403	Potentially Relevant and Appropriate	Sets pretreatment standards through the National Categorical Standards of the General Pretreatment Regulations for the introduction of pollutants from non-domestic sources into publicly owned treatment works (POTWs) in order to control pollutants that pass through, cause interference, or are otherwise incompatible with treatment processes at a POTW.	If groundwater is discharged to a POTW or the FOTW, the discharge must meet local limits imposed by the POTW. A discharge from a CERCLA site must meet the POTW's pretreatment standards in the effluent of the POTW. Discharge to a POTW is considered an offsite activity and is, therefore subject to both the substantive requirements of this rule.
RCRA Regulations, General Facility Standards	40 CFR Subpart B, 264.10-264.18	Potentially Relevant and Appropriate	Sets the general facility requirements including general waste analysis, security measures, inspections, and training requirements. Section 264.18 establishes that a facility located in a 100-year floodplain must be designed, constructed, and maintained to prevent washout of any hazardous wastes by a 100-year flood.	If the remedial action involves construction of an onsite treatment facility, such as a groundwater treatment facility, the substantive requirements of this rule would be applicable requirements. A permitted treatment facility must be selected for offsite treatment. These regulations do not apply to the aboveground treatment or storage of hazardous waster before it is injected into underground. However, this rule may be an applicable requirement for alternatives that do not involve groundwater reinjection.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
RCRA Regulations, Miscellaneous Units	40 CFR Part 264, Subpart X	Potentially Relevant and Appropriate	These standards are applicable to miscellaneous units not previously defined under existing RCRA regulations. Subpart X outlines performance requirements that miscellaneous units be designed, constructed, operated, and maintained to prevent releases to the subsurface, groundwater, and wetland that may have adverse effects on human health and the environment.	The design of proposed treatment alternatives, not specifically regulated under other subparts of RCRA, must prevent the release of hazardous constituents and future impacts on the environment. This subpart would apply to onsite construction of any treatment facility that is not previously defined under the RCRA regulation.
RCRA Regulations, Preparedness and Prevention	40 CFR Part 264, Subpart C	Potentially Relevant and Appropriate	Outlines requirements for safety equipment and spill control for hazardous waste facilities. Facilities must be designed, maintained, constructed, and operated to minimize the possibility of an unplanned release that could threaten human health or the environment.	Safety and communication equipment would be incorporated into all aspects of the remedial process and local authorities would be familiarized with site operations.
RCRA Regulations, Releases from Solid Waste Management Units (SWMUs)	40 CFR Part 264, Subpart F	Potentially Relevant and Appropriate	Establishes the requirements for SWMUs at RCRA regulated treatment, storage, and disposal (TSD) facilities. The scope of the regulation encompasses groundwater protection standards, point of compliance, compliance period, and requirements for groundwater monitoring.	These regulations would be followed for the treatment of hazardous waste.

TABLE 2-5

FEDERAL ACTION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
RCRA Regulations, Standards for Owners and Operators of Hazardous Waste TSD Facilities	40 CFR Part 264	Potentially Relevant and Appropriate	Establishes minimum national standards defining the acceptable management of hazardous wastes for owners and operators of facilities that treat, store, or dispose of hazardous wastes.	If remedial actions involving management of RCRA wastes at an off-site TSD Facility or if RCRA wastes are managed onsite, the requirements of this rule would be followed.
RCRA Regulations, Use and Management of Containers	40 CFR Part 264, Subpart I	Potentially Relevant and Appropriate	Sets standards for the storage of containers of hazardous waste.	This requirement would apply if a remedial alternative involves the storage of a hazardous waste (i.e. contaminated groundwater) in containers, prior to treatment.
SWDA Regulations, Underground Injection Control Regulations	40 CFR Parts 144, 146, 147, and 1000	Potentially Relevant and Appropriate	Establishes minimum program and performance standards for underground injection programs. Technical criteria and standards for siting, operation, maintenance, reporting, and recordkeeping are included in Part 146. Also requires protection of underground sources of drinking water.	Discharge of treated groundwater, by well injection, would be in accordance with all criteria and standards in these regulations, as well as meet all State Underground Injection Control Program requirements. Treated groundwater would meet all SWDA standards for reinjection prior to well injection.

TABLE 2-6

STATE ACTION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Florida Hazardous Waste Rules – October, 1993	FAC Chapter 62-730	Potentially Applicable	Adopts by reference sections of the Federal hazardous waste regulations and establishes minor additions to these regulations concerning the generation, storage, treatment, transportation and disposal of hazardous wastes.	These regulations would apply if waste onsite were deemed hazardous and needed to be stored, transported, or disposed of properly.
Florida Drinking Water Standards	FAC Chapter 62-550	Potentially Applicable	This rule adopts Federal primary and secondary drinking water standards	These regulations would apply to remedial activities that involve discharges to potential sources of drinking water.
Florida Wetland Application Regulations – November, 1989	FAC Chapter 62-611	Potentially Applicable	Sets requirements for discharge of domestic wastewater to wetland. This rule mainly addresses the discharge of domestic wastewater to wetlands. Discharge limits are established for BOD, TSS, nitrogen, and phosphorus.	This rule would be considered for remedial alternatives that would result in discharges to wetlands where these limits may be approached.
Florida Wastewater Facility Permits	FAC Chapter 62-620	Potentially Applicable	This rule establishes requirements for wastewater permits. It was published in November 1994; however, it is not effective until Florida is recognized as a “delegated” state.	Upon delegation, facilities in Florida requiring a wastewater permit will meet the permitting requirements under this rule. Upon Florida becoming a “delegated” state, facilities will be allowed to have a single permit to meet both Federal and State discharge requirements.
Florida Regulation of Stormwater Discharge –May, 1993	FAC Chapter 62-25	Potentially Relevant and Appropriate	Establishes requirements for discharges of untreated stormwater to ensure protection of the surface water of the state.	Remedial actions would consider the impact of the discharge of untreated stormwater.

TABLE 2-6

STATE ACTION-SPECIFIC ARARs
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Requirement	Citation	Status	Synopsis	Evaluation/Action to be Taken
Florida Underground Injection Control Regulations – April,1989	FAC Chapter 62-28	Potentially Applicable	Establishes a State Underground Injection Control Program consistent with federal requirements and appropriate to the hydrogeology of Florida.	These regulations would be considered if remedial actions involve underground injection.
Florida Groundwater Permitting and Monitoring Requirements – April, 1994	FAC Chapter 62-522	Potentially Applicable	Establishes permitting and monitoring requirements for installations discharging to groundwater.	The substantive requirements of this rule would be met when discharge to groundwater is a possible remedial action. If these requirements are met under another permit, a separate discharge permit may not be required.
Florida Water Well Permitting and Construction Requirements – March, 1992	FAC Chapter 62-532	Applicable	Establishes minimum standards for the location, construction, repair, and abandonment of water wells. Permitting requirements and procedures are established.	The substantive requirements for permitting would be met if remedial actions involve the construction, repair, or abandonment of monitoring, extraction, or injection wells.
Florida Rules on Hazardous Waste Warning Signs – July, 1991	FAC Chapter 62-736	Applicable	Requires warning signs at NPL and FDEP identified hazardous waste sites to inform the public of the presence of potentially harmful conditions.	This requirement will be met.
Florida Rules on Permits – November,1994	FAC Chapter 62-4	Potentially Applicable	Establishes procedures for obtaining permits for sources of pollution. This rule also establishes a “mixing zone” rule for facilities that discharge wastewater into the surface waters of the state.	These substantive requirements would be met during remediation. Through dilution, applying the “mixing zone” rule allows wastewater with higher concentrations of pollutants to be discharged into surface water, while still maintaining the Florida water quality standards.

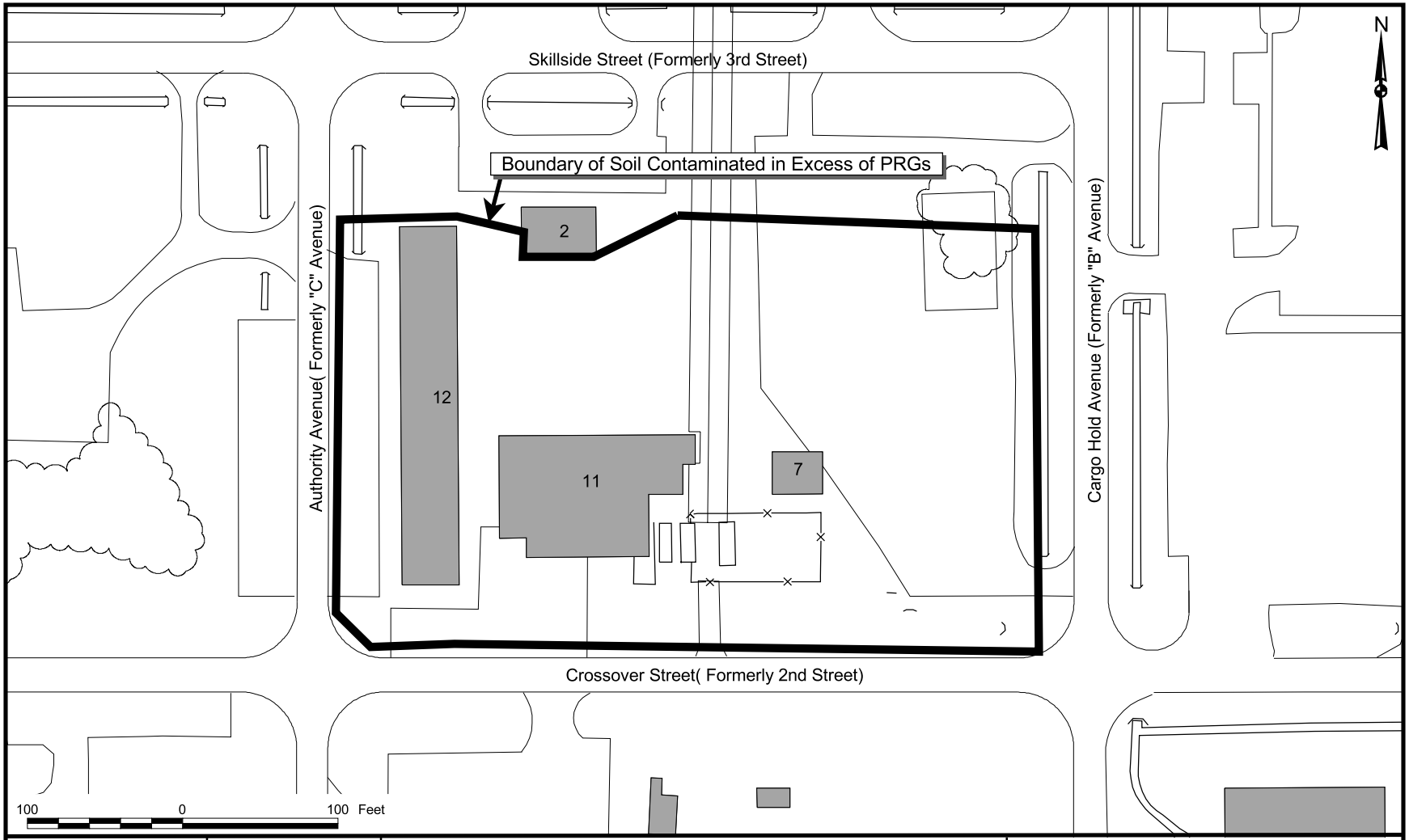
2.4.1 Estimated Volume of Contaminated Soil

Based upon the analytical results of the post-removal action sampling (TtNUS, 2001) and the agreement reached by the BCT (BCT, 2001), it was established that the area of soil contaminated in excess of PRGs extends over most of Site 45, covering approximately 2.8 acres or 121,900 square feet (ft^2), from south of Building 2 to Crossover Street and from Authority Avenue to just short of Cargo Hold Avenue, as shown on Figure 2-1.

Soil contamination is estimated to extend down to 2 ft bgs. Taking into account existing Buildings 7, 11, and 12, this corresponds to a total volume of contaminated soil of approximately 7,800 cubic yards (yd^3).

2.4.2 Estimated Volume of Contaminated Groundwater

Based on the analytical results of the RI, it was established the that groundwater contaminant plume where vanadium concentration exceeds the PRG extends over an area approximately 28,600 ft2 in size and down to a depth of up to 35 ft bgs. Based on a water table elevation of 5 ft bgs and a porosity of 0.25 that are typical at NAS Cecil Field, the estimated volume of contaminated groundwater at Site 45 was computed at 214,500 ft^3, or 1,605,000 gallons. Computations of contaminated groundwater volume are presented in Appendix A.



DRAWN BY MJJ	DATE 30Jun00	EXTENT OF SOIL CONTAMINATED IN EXCESS OF PRGs OU 11, SITE 45 FEASIBILITY STUDY REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2-1 / REV 0

P:\GIS\NAS_CecilField\PSC45_FS.apr 04Jun01 MJJ 2-1 Layout

3.0 SCREENING OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

This section identifies, screens, and evaluates the potential remediation technologies and process options that may be applicable to assemble groundwater remedial alternatives for Site 45 at NAS Cecil Field. The primary objective of this phase of the FS is to develop an appropriate range of remedial technologies and process options that will be used for developing remedial alternatives.

The basis for remediation technology identification and screening began in Section 2.0 with a series of discussions that included the following:

- Identification of ARARs
- Development of RAOs
- Identification of GRAs
- Identification of volumes or areas of media of concern

Remediation technology screening is performed in this section with the completion of the following analytical steps:

- Identification and screening of remediation technologies and process options
- Evaluation and selection of representative process options

In this section a variety of remediation technologies and process options is first identified for each of the GRAs listed in Section 2.3.1 and then screened. The selection of remediation technologies and process options for initial screening is based on the “Guidance for Conducting Remedial Investigations/Feasibility Studies under CERCLA” (USEPA, 1988). The screening is first conducted at a preliminary level to focus on relevant remediation technologies and process options. Then the screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected to represent the remediation technologies that have passed the detailed evaluation and screening.

The evaluation criteria for detailed screening of remediation technologies and process options that have been retained after the preliminary screening are effectiveness, implementability, and cost. The following are descriptions of these evaluation criteria:

- Effectiveness
  - Protection of human health and environment; reduction in toxicity, mobility, or volume; and permanence of solution.
  - Ability of the technology to address the estimated areas or volumes of contaminated medium.
  - Ability of the technology to attain the PRGs required to meet the RAOs.
  - Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions.

- Implementability
  - Overall technical feasibility at the site.
  - Availability of vendors, mobile units, storage and disposal services, etc.
  - Administrative feasibility.
  - Special long-term considerations (e.g., maintenance and operation requirements).

- Cost (Qualitative)
  - Capital cost.
  - Operation and maintenance (O&M) costs.

3.1 PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens remediation technologies and process options for soil at a preliminary stage based on implementation with respect to site conditions and contaminants of concern. Table 3-1 summarizes the preliminary screening of technologies and process options applicable to soil. It presents the general response actions, identifies the technologies and process options, and provide a brief description of each process option followed by the screening comments.

The following are the soil remediation technologies and process options retained for detailed screening:

TABLE 3-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not applicable	No activities conducted at the site to address contamination.	Required by NCP. Retain for baseline comparison to other technologies.
Limited Action	Institutional Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, warning signs, and monitoring to restrict site access.	Eliminate. Direct exposure to soil is acceptable under the industrial land use scenario.
		Passive Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Retain to prevent future residential development.
	Monitoring	Sampling and Analysis	Sampling and analysis of soil and groundwater to evaluate natural attenuation and migration of COCs in the environment.	Retain to assess natural attenuation and/or migration of COCs from site and to evaluate progress of remedial actions.
Containment	Capping	Soil/Multimedia Cover	Use of semi-permeable or impermeable barriers to minimize direct exposure to contaminated soil and potential migration of COCs to groundwater.	Retain.
	Erosion control	Rip-rap cover/vegetation	Use of gravel/cobbles or dense plant growth to minimize migration of contaminated soil.	Eliminate because erosion is not a significant migration pathway due to the flat nature of the terrain.
Removal	Bulk excavation	Excavation	Use of construction equipment such as backhoe, front-end loader, gradall, etc.. to remove contaminated soil.	Retain.
In-situ Treatment(1)	Thermal	Vitrification/ Radiofrequency Heating	Use of high-temperature melting to fuse inorganic COCs into a glass matrix or of moderate temperature heating to volatilize COCs and remove them from the soil.	Eliminate because of implementability concerns due to shallow groundwater table elevation.

TABLE 3-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-situ Treatment[1] (continued)	Physical/ Chemical	Soil Flushing	Use of water or other solvents to remove COCs by flushing and collecting and treating or disposing of the contaminated fluids.	Eliminate because BaPEq and TRPH are not particularly soluble, soil has low hydraulic conductivity, and the water table is shallow.
		Dynamic Underground Stripping	Injection of steam at the periphery of the contaminated area to volatilize COCs and removal of these COCs through a centrally located extraction well.	Eliminate because site COCs are not particularly volatile and this technology mostly applies to highly-contaminated soil.
		Soil Vapor Extraction	Use of vacuum and possibly air sparging to volatilize COCs.	Eliminate because COCs are not particularly volatile.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents in the vadose zone to chemically fix COCs and solidify the matrix.	Eliminate because this technology would not address BaPEq and TRPH.
Ex-situ Treatment	Physical/ Chemical	Soil Washing/Solvent Extraction	Use of water or other solvents to remove COCs by flushing and collecting and treating or disposing of the contaminated fluids.	Eliminate because BaPEq and TRPH are not particularly soluble and soil is not very permeable.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents to chemically fix COCs and solidify the matrix.	Retain for the potential offsite treatment of arsenic. Would not address BaPEq and TRPH.
	Biological	Onsite Landfarming	Spreading and tilling of contaminated soil into layers of clean surface soil to aerate and biodegrade organic COCs.	Eliminate because this would not address arsenic and no on base area is available for this purpose.
		Bioslurry Reactor/Biopile	Treatment of soils in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic COCs.	Retain for the potential offsite treatment of BaPEq and TRPH. Would not address arsenic.

TABLE 3-1

PRELIMINARY SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-situ Treatment (continued)	Thermal	Incineration	Use of high temperatures to destroy COCs.	Retain for the potential offsite treatment of BaPEq and TRPH. Would not address arsenic.
		Low-Temperature Thermal Desorption (LTTD)	Use of low to moderate temperatures to volatilize COCs and remove them from soil.	Retain for the potential offsite treatment of BaPEq and TRPH. Would not address arsenic.
	Solids Processing	Crushing/Grinding	Size reduction of wastes as a preliminary process to aid in downstream treatment.	Retain as pretreatment step for other processes.
		Screening	Removal/segregation of material based on size as a preliminary process to aid in downstream treatment.	Retain as pretreatment step for other processes.
Disposal	Landfill	On-Site Landfilling	Disposal of excavated soil and treatment residues in an on-base landfill..	Eliminate because no suitable on-base area is available for this purpose.
		Off-Site Landfilling	Disposal of excavated soil and treatment residues in an off-base permitted TSDF.	Retain.

Notes:

1 Additional screening of in-situ treatment technologies is provided in the technical memorandum attached as Appendix D and entitled: "Summary of Treatability Testing Options to Evaluate Technologies for the In-situ Treatment of Vanadium in Groundwater".

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	Institutional Controls	Land Use Controls (LUCs)
	Monitoring	Sampling and Analysis
Containment	Capping	Soil/ Multimedia Cover
Removal	Bulk excavation	Excavation
Ex-situ Treatment	Physical/Chemical	Off-Base Chemical Fixation/Solidification
	Biological	Off-Base Bio-Slurry Reactor/Bio-Pile
	Thermal	Off-Base Incineration
		Off-Base Low-Temperature Thermal Desorption (LTTD)
	Solids Processing	Screening/Crushing/Grinding
Disposal	Landfill	Off-Base Landfilling

3.2 DETAILED SCREENING OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

3.2.1 No Action

No Action consists of maintaining status quo at the site. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternative and their effectiveness in mitigating risks posed by site contaminants. Since no remedial actions are taken under this alternative, there are no costs associated with “walking away from” the site. There is also no reduction in risk through exposure control or treatment. No action would not be effective in evaluating contaminant mobility and potential migration off-site since no monitoring would be performed.

Effectiveness

No Action would not be effective in meeting the RAOs. No Action would not be effective in evaluating either potential contaminant reduction through natural attenuation or potential contaminant migration off-site since no monitoring would be performed.

Implementability

There would be no implementability concerns since no action would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No Action is retained because of NCP requirements although it would not be effective.

3.2.2 Limited Action

3.2.2.1 Institutional Controls

Institutional controls would consist of preparing and implementing a Land Use Control Implementation Plan (LUCIP), including deed restrictions to prevent the site from being used in the future as a residential area.

Effectiveness

Prohibiting future residential development of the site would effectively prevent the occurrence of unacceptable risks from direct exposure of human receptors with contaminated soil. Institutional controls would not be effective to protect ecological receptors from potential exposure to contaminated soil but, since Site 45 constitutes a relatively unlikely ecological habitat, unacceptable risks to ecological receptors would be minimal.

Implementability

Institutional controls would be readily implementable. As part of change of the site from military to private ownership provisions will be incorporated in property transfer documents to insure the continued implementation of institutional controls. Resources are readily available for the preparation of deed restrictions.

Cost

Costs of institutional controls would be low.

Conclusion

Institutional controls are retained in combination with other process options for the development of remedial alternatives.

3.2.2.2 Monitoring

Sampling and analysis of soil throughout the area of potential contamination would be used to evaluate potential for contaminant migration to the groundwater and subsequent contamination of onsite drinking

water supply and nearby residential, municipal and commercial wells. Groundwater sampling and analysis would also be conducted to determine if contaminant migration is occurring from the soil to the groundwater.

Effectiveness

Monitoring alone would not reduce the toxicity, mobility, or volume of contaminants in the soil. However, monitoring would allow for a determination to be made of the potential off-site migration of contaminants or of the potential reduction in contaminant concentrations through natural attenuation.

Implementability

A sampling and analysis program could be readily implemented.

Cost

Capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained in combination with other process options for the development of remedial alternatives.

3.2.3 Containment

The only technology considered under this GRA is capping. Capping would consist of providing a horizontal barrier to minimize the extent of potential contaminant migration to surface water through soil erosion and/or to groundwater through percolation of precipitation through the vadose zone.

Effectiveness

Capping would be effective in preventing potential receptors from direct contact with the contaminated soil. The cap would also be effective in minimizing the migration of contaminants in the environment by reducing the infiltration into the contaminated soil layer underlying the cap. Long-term maintenance of the cap and long-term monitoring would ensure that the cap is effective in minimizing migration of contaminants. Exposure to on-site workers during installation of the cap or monitoring could be easily controlled.

Implementability

Installation of a cap at Site 45 would be hard to implement. The construction of a cap would impact the future site use that will be further complicated when the site becomes non-military. The numerous existing structures at the site, including Buildings 2, 7, 11, and 12 and parking facilities would need to be considered prior to the construction of the cap. Materials and services required to implement this technology are readily available.

Cost

Capital and O&M costs for capping would be low to moderate.

Conclusion

Capping is eliminated from further consideration because of implementability concerns.

3.2.4 Removal

The only technology considered under this GRA is excavation. Excavation can be performed by a variety of equipment, such as tractor shovels (front-end loaders), backhoes, grade-alls, etc. The type of equipment selected must take into consideration several factors, such as the type of material to be removed, the load-bearing capacity of the ground surrounding the removal area, the depth and areal extent of removal, the required rate of removal, and the elevation of the groundwater table. Excavation is the technology of choice for the removal of well consolidated material, such as soil, to depth of up to 30 feet and from well-defined areas of ground with significant load bearing capacity (i.e., greater than 1,500 pounds per square foot).

The logistics of excavation must take into account the available space for operating the equipment, loading/unloading to transport the removed material, location of the site, etc. Once excavation is completed, the location is filled and graded with clean fill material or treated soils. Because of the proximity to the flightline, dust and debris produced as a result of the remedial action must be strictly controlled.

Effectiveness

Excavation is a well-proven and effective method of removing contaminated material from a site. Properly designed excavation would remove most of the soil contaminated above PRGs and remaining soil would not pose an unacceptable risk to human health or the environment. Fill material and contaminated sandy/silty soils, such as those at Site 45, would be amenable to excavation.

Sampling is typically required to verify the effectiveness of the removal action. Soil samples would be collected from the sidewalls and, as applicable, from the bottom of the excavation. These samples would be analyzed for COCs to ensure that the remaining soil is not contaminated at unacceptable levels.

Implementability

Excavation of contaminated soil at Site 45 would be implementable. Excavation equipment and/or services are readily available from multiple vendors or contractors. This technology is well proven and established in the construction/remediation industry. During excavation, site-specific health and safety procedures and Occupational Safety and Health Act (OSHA) regulations would have to be complied with to ensure that the exposure of the workers to COCs is minimized. This would include, the wearing of appropriate personal protective equipment (PPE) and the implementation of dust suppression measures.

Since the excavation depth would be limited to a depth of 2 feet bgs, the need for shoring and dewatering would be minimal. Care would have to be taken not to undermine the foundations of existing buildings.

Cost

Cost of excavation at Site 45 would be moderate.

Conclusion

Excavation is retained in combination with other process options for the development of remedial alternatives.

3.2.5 Ex-Situ Treatment

3.2.5.1 Off-Base Chemical Fixation/Solidification

Chemical fixation/solidification would consist of mixing the contaminated material to be treated, typically a soil or sludge, with chemical reagents that bind the contaminants within the matrix of the material being treated. The most common fixation/solidification reagents are pozzolanic-based materials such as Portland Cement, cement kiln dust (CKD), and fly ash. Chemicals such as quick lime or proprietary reagents (e.g., organophilic compounds) are also often added to the fixation/solidification reagents to increase their effectiveness of the treatment, especially if organic contaminants are present which may not readily respond to pozzolanic-based binding. Quick lime is often added to reduce the solubility of metals and neutralize acidity, which would otherwise destroy the cementitious matrix and release the metals into the environment.

The mixing of the material to be treated with the chemical reagents is normally accomplished in the presence of a controlled amount of water with specialized mechanical blending equipment, such as a pug mill.

After the material is mixed with the chemical reagents, it is allowed to cure for a specified time period. The duration of curing is dependent on the strength required before handling or disposal. The solidified material can be formed into monolithic blocks or can be made into a granular material with the consistency of a soil-cement.

Effectiveness

The effectiveness of chemical fixation/solidification is highly dependent on the type of material being treated and the kind of contaminant(s) being immobilized; therefore, the process must be designed to accommodate each specific application. A thorough physical and chemical characterization of the material to be treated and contaminant(s) to be immobilized is needed and treatability testing must typically be performed to determine the most suitable fixation/solidification reagents, the mixing ratios, and any special pretreatment or material handling methods that may be required.

At Site 45, pozzolanic fixation/solidification would very likely be effective for the treatment of soil contaminated with and arsenic and BaPEq and that portion of contaminated soil with a TRPH concentration of 100 mg/kg or less. However, pozzolanic fixation/solidification would probably not be effective for the treatment of contaminated soil with a TRPH concentration in excess of 100 mg/kg, unless that concentration has first been reduced through some other type of treatment technology. Because chemical fixation/solidification would not reduce contaminant toxicity, the treated soil would still require proper disposal to minimize the unacceptable human health risk that could result from direct exposure. Chemical fixation/solidification would effectively minimize the potential for migration of contaminants from the treated soil to other environmental media, such as groundwater. Long-term stability and leachability of the treated soil would remain as potential concerns because contaminants would remain within the treated soil. Most chemical fixation/solidification processes, including in particular the use of pozzolanic reagents result in an increase in the volume of the treated material typically ranging from 5 to 15 percent.

Implementability

Off-base chemical fixation/solidification would be readily implementable. The necessary equipment and resources are available at most permitted treatment and disposal facilities (TSDFs) to perform this work. Treatability tests would be required to determine the appropriate mix ratios prior to implementation.

Cost

Capital and O&M costs of off-base pozzolanic fixation/solidification would be moderate.

Conclusion

Chemical fixation/solidification is retained for further consideration as an effective technology for the off-base treatment of excavated soil prior to final disposal.

3.2.5.2 Off-Base Bio-slurry Reactor/Bio-pile

Bio-slurry reactor is a technology in which the excavated soil is biologically treated in an enclosed vessel. After removal of foreign materials, such as stones and rubble, the contaminated soil is mixed with water to form a slurry containing 10 to 30 percent solids and placed in a tank featuring process controls so that temperature, mixing, and nutrient additions can be manipulated to achieve maximum efficiency. Following treatment, the soil slurry is dried and tested to verify that contaminants have been adequately removed and the treated soil is replaced in its original location or used as fill material somewhere else.

Bio-pile technology is a technology in which the excavated soil is mixed with soil amendments and formed into compost piles and enclosed for biological treatment. Oxygen is provided either by the inducing of an air current through the pile with blowers or vacuum pumps or by the mixing-in of a oxygen-release reagent. Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation. Duration of operation may vary from a few weeks to several months, at which time the treated soil is either returned to its original location or used as fill material somewhere else.

Effectiveness

Bio-slurry reactors and bio-piles have been proven effective for the treatment of soil contaminated with organic compounds, such as the BaPEq and TRPH detected at Site 45. Typically, treating of such soil in bio-slurry reactors or bio-piles can achieve close to 100 percent removal of these compounds. Treatability testing would typically be required to determine the biodegradability of contaminants and appropriate oxygenation and nutrient loading rates.

Static bio-pile technology is slower and may result in less uniform treatment than bio-slurry reactor technology that involves continuous mixing. If air injection or vacuum is used to supply oxygen, exhaust gases may contain VOCs and require treatment prior to discharge to the atmosphere.

Implementability

Off-base bio-slurry reactor or bio-pile technologies would be implementable but either one would require a relatively complex sequence of operations, including staging, treatment, and disposal of treated soil. In addition, treated soil from a bio-slurry reactor would also require dewatering and drying prior to disposal. Equipment and resources may not be readily available to implement either of these technologies at most permitted TSDFs.

Cost

Capital and O&M costs for off-base bio-slurry reactors/bio-piles would be moderate to high.

Conclusion

Off-base bio-slurry reactors/bio-piles are eliminated from further consideration because of effectiveness and implementability concerns.

3.2.5.3 Off-Base Incineration

Incineration is a thermal oxidation process that converts organic solids, liquids, and gases to inorganic substances at high temperatures in the presence of oxygen. The technology uses controlled flame combustion in an enclosed reactor to decompose organics. Carbon and hydrogen waste components are converted to carbon dioxide (CO_2) and water, respectively. Other combustion products are also present in smaller quantities. These may include carbon monoxide, nitrogen oxides, chlorine, fluorine, and trace metals. If a wet scrubber air pollution control system is used, a liquid waste stream could also be generated. Screening of the contaminated material would be required to remove the noncombustible waste/debris from the soils. The noncombustible waste/debris must be treated or disposed of by other means, depending upon the level of contamination associated.

Rotary kilns are one of the most widely used incinerators for wastes in the form of solids, sludges, liquids, and gases. An integrated system for incineration by rotary kiln includes a solid feed system; a rotary kiln and secondary combustion chamber; air pollution control units for particulate and acid gas removal; and an exhaust stack. Such a system employs a refractory-lined rotary kiln operating at high temperatures (1,470 to 2,910°F or 800 to 1,600°C) to combust wastes in the presence of oxygen. A typical throughput for a transportable rotary kiln is 75 to 200 tons per day. For wastes that have a high heat content, the throughput may be limited by the capacity of the unit to control the heat generation rate. Fixed-based units, such as cement kilns that may be permitted to accept contaminated soils, are also available.

Effectiveness

Incineration would be very effective for destroying the organic COCs in the soil. Incineration would typically achieve in excess of 99.99 percent destruction of organic contaminants with the resulting formation of inert carbon dioxide and water. Incinerated soil could typically be reused as fill material.

Implementability

Off-base incineration would be relatively easy to implement and would only require pre-approval of the waste. Qualified TSDFs would be readily available to provide the required services.

Cost

Cost of off-base incineration would be high to very high.

Conclusion

Off-base incineration is eliminated from further consideration because, although it would be effective, this degree of treatment is not required to successfully remove the relatively moderate concentrations of organic compounds in the Site 45 soil.

3.2.5.4 Off-Base Low Temperature Thermal Desorption (LTTD)

LTTD technology uses direct or indirect heating to thermally desorb or volatilize organic contaminants. The temperatures used are contaminant- and matrix-specific, with a range of approximately 200 to 1,200°F (95 to 650°C). Typically, wastes are processed through an externally fired pug mill or rotary drum system equipped with heat transfer surfaces that are heated by circulating hot oil. An induced airflow conveys the desorbed organic chemicals through a secondary treatment system, such as a granular activated carbon (GAC) adsorption unit, a catalytic oxidation unit, a condenser unit, or even an afterburner. It should be noted, however, use of an afterburner for secondary treatment has typically resulted in the LTTD unit being considered as an incinerator by regulatory agencies. The off-gas is then discharged through a stack.

Effectiveness

The effectiveness of LTTD is highly contaminant- and matrix-specific. Therefore a full characterization of the waste to be treated would be required and treatability testing would have to be performed to verify the level of effectiveness and determine the optimum operating temperature and detention time. LTTD

effectiveness is very sensitive to particle size, therefore, pre-treatment would likely be required with size separation and crushing-grinding-shredding.

LTTD would likely be very effective for the removal of the organic COCs from contaminated soil at Site 45 and, since these contaminants are semi-volatile BaPEq and TRPH, the operating temperature would be expected to be towards the higher end of the range (probably 800 to 900º F).

To be fully effective, LTTD would require additional treatment of the volatilized contaminants which would be accomplished through treatment of off-gases by such processes as condensation, vapor-phase GAC adsorption, or catalytic oxidation.

Implementability

Off-base treatment of contaminated soil with LTTD would be implementable. Qualified TSDFs would be readily available to provide the necessary services. Pre-treatment of the excavated material for size separation and/or reduction would most likely be required and could be accomplished on site. Off-gases from the thermal desorption unit would have to be treated. Treatability testing may have to be performed.

Cost

Costs of off-base LTTD would be moderate.

Conclusion

Off-base LTTD is retained in combination with other processes for the development of remedial alternatives.

3.2.5.5 Crushing/Grinding/Shredding

Crushing/grinding/shredding would consist of reducing the size of contaminated debris so that they would meet the particle size requirements of subsequent treatment processes. This size reduction is accomplished by processing the oversized contaminated debris in specialized mechanical equipment such as hammer mill, grinders, and shredders.

Effectiveness

Crushing/grinding/shredding would not of itself be effective for contaminant removal. However, crushing/grinding/shredding would be effective and is often required as a pre-treatment to optimize the effectiveness of other treatment processes, such as LTTD or incineration.

During operation, risk to site workers operating the size reduction equipment could be adequately minimized through the use of dust suppression controls, the wearing of appropriate PPE, and compliance with OSHA regulations and site-specific health and safety procedures.

Implementability

Crushing/grinding/shredding would be readily implementable as a pretreatment step. The equipment and labor to operate this equipment would be readily available.

Due to the proximity to the flightline, dust, dirt, and debris would be strictly controlled.

Cost

Capital and O&M costs for crushing/grinding/shredding would be low.

Conclusion

Crushing/grinding/shredding is retained in combination with other process options for the development of remedial alternatives.

3.2.6 Disposal

The only technology considered under this GRA is off-base landfilling. Off-base landfilling consists of transporting the excavated soil for burial in a permitted off-base TSDF. RCRA non-hazardous waste may be disposed of in an RCRA Subtitle D, or solid waste, landfill. RCRA-hazardous waste must be disposed of in an RCRA Subtitle C, or hazardous waste, landfill. It is anticipated that the excavated soil would be classified as RCRA non-hazardous.

Effectiveness

Off-base landfilling does not permanently or irreversibly reduce contaminant concentrations. However, although CERCLA preference for treatment relegates landfilling to a less preferable option, this technology can be an effective disposal option for contaminated soil. Off-base landfills are only permitted to operate if they meet certain requirements of design and operation governing foundation, liner, leak detection, leachate collection and treatment, daily cover, post-closure inspections and monitoring, etc., which ensure the effectiveness of these facilities. The requirements of a RCRA Subtitle C hazardous waste landfill are typically more stringent than those of a RCRA Subtitle D solid waste landfill.

Implementability

Off-base landfilling would be easily implementable. Permitted TSDFs are available for this purpose. Disposal at RCRA Subtitle D solid waste landfill may require certain pre-treatment, mainly the removal of free liquids but, since soil would only be excavated to the groundwater table, this requirement should be easy to meet. In addition, a waste profile would have to be prepared, including indication of contaminant concentrations and their leachability.

Cost

Cost of off-base landfilling would be low to moderate.

Conclusion

Off-base landfilling is retained in combination with other process options for the development of remedial alternatives.

3.3 SELECTION OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

The following remediation technologies and process options are retained to develop soil remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- Excavation
- Off-Base Chemical Fixation/Solidification
- Off-Base LTTD
- Crushing/Grinding/Shredding
- Off-Base landfilling

3.4 PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

This Section identifies and screens remediation technologies and process options for groundwater at a preliminary stage based on implementation with respect to site conditions and contaminants of concern. Table 3-2 summarizes the preliminary screening of remediation technologies and process options applicable to groundwater. This table presents the GRAs, identifies the remediation technologies and

process options, and provides a brief description of each process option followed by a screening comment.

The following are the groundwater remediation technologies and process options remaining for detailed screening:

General Response Action	Remediaton Technology	Process Options
No Action	None	Not Applicable
Limited Action	Monitoring	Sampling and Analysis
	Institutional Controls	Land Use Controls and Groundwater Use Restrictions
	Natural Attenuation	Naturally-Occurring Dispersion and Dilution
Removal	Groundwater Extraction	Extraction Wells or Trenches
In-situ Treatment	Physical/Chemical	Permeable Reactive Barriers
Ex-situ Treatment	Physical	Sedimentation
		Filtration
		Granular Activated Carbon Adsorption
		Reverse Osmosis
	Chemical	Neutralization/pH Adjustment
		Coagulation/Flocculation
		Ion Exchange
Discharge/Disposal	Onsite Surface Discharge	Direct Discharge (NPDES)
		Indirect Discharge (IWTP/STP)

3.5 DETAILED SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

3.5.1 No Action

No action consists of maintaining status quo at the site. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternative and their effectiveness in mitigating risks posed by site contaminants. Since no remedial actions are conducted under this alternative, there are no costs associated with “walking away from” the site. Neither is there a reduction in risk through exposure control or treatment.

Effectiveness

No Action would not be effective in meeting the RAOs for the site. No Action would not be effective in evaluating either potential contaminant reduction through natural attenuation or potential contaminant migration off-site since no monitoring would be performed.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by NCP. Retain for baseline comparison to other technologies.
Limited Action	Monitoring	Sampling and Analysis	Periodic sampling and analysis of groundwater and other media to track the spread of contamination.	Retain to assess natural attenuation and/or migration of contaminants from site and evaluate remedial actions.
	Institutional Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, and warning signs to restrict site access.	Eliminate – plume is beneath an active commercial-industrial area.
		Passive Controls: Deed and Land Use Restrictions	Administrative action using property deeds to restrict future site activities and use of groundwater.	Retain to limit human exposure to contaminated groundwater.
	Natural Attenuation	Naturally-Occurring Biodegradation and Dilution	Monitoring the groundwater to assess the contaminant dilution or degradation.	Retain
Containment	Vertical Barriers	Slurry Wall	Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater.	Eliminate – existing structures would severely restrict constructibility and the depth of the nearest impervious layer makes this technology impractical.
		Grout Curtain	Pressure injection of grout to form a low-permeability perimeter wall to restrict horizontal migration of groundwater.	Eliminate – existing structures would severely restrict constructibility and the depth of the nearest impervious layer makes this technology impractical.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Technology	Process Options	Description	Screening Comment
Containment (Continued)	Vertical Barriers (Continued)	Sheet Piling	Metal sheet piling driven into the ground to restrict horizontal migration of groundwater.	Eliminate – existing structures would severely restrict constructibility and the depth of the nearest impervious layer makes this technology impractical.
		Hydraulic Barrier	Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater.	Eliminate – no suitable area exists reasonably close to Site 45 for reinjection.
	Horizontal Barriers	Physical Barrier	Injection of bottom sealing slurry beneath source to minimize vertical migration of groundwater.	Eliminate – existing structures would severely restrict constructibility of such a barrier.
Removal	Groundwater Extraction	Extraction Wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain to remove contaminated groundwater.
		Collection Trench	A permeable trench used to intercept and collect groundwater.	Retain to remove contaminated groundwater.
In-situ Treatment	Biological	Aerobic	Enhancement of biodegradation in an aerobic environment by addition of chemical additives.	Eliminate – vanadium is not amenable to biological degradation.
		Anaerobic	Enhancement of biodegradation in an anaerobic (oxygen-deficient) environment by addition of chemical additives.	Eliminate – vanadium is not amenable to biological degradation.
	Physical/ Chemical	Air Sparging/ Soil Vapor Extraction	Volatilization and enhancement of biodegradation by supply of air and extraction of vapors.	Eliminate – vanadium is not amenable to volatilization or biological degradation.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Technology	Process Options	Description	Screening Comment
In-situ Treatment (Continued)	Physical/ Chemical (Continued)	Permeable Reactive Barrier (PRB)	Use of a permeable barrier that allows the passage of groundwater and reacts with the contaminants.	Retain for the in-situ treatment and immobilization of dissolved vanadium.
		Fenton's Reagent	Chemical treatment of contaminants through oxidation using a solution of ferrous iron and dilute hydrogen peroxide.	Eliminate – unproven effectiveness for the treatment of inorganic compounds and inappropriate for low concentrations.
Ex-situ Treatment	Physical	Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Retain as a pretreatment step prior to potential treatment processes.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials from water.	Retain for the removal of dissolved vanadium.
		Air Stripping	Contact of water with air to remove volatile compounds.	Eliminate – vanadium is not amenable to volatilization.
		Granular Activated Carbon (GAC) Adsorption	Separation of dissolved contaminants from water via adsorption onto GAC.	Retain for removal of low concentrations of dissolved metals, including vanadium.
		Solvent Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern.	Eliminate - not normally applicable to inorganic compounds and not effective for the removal of low concentrations.
		Enhanced Oxidation	Use of oxidizers such as air, ozone, peroxide, chlorine, or permanganate, or use of high pressure/temperature to chemically increase the oxidation state of organic and inorganic compounds.	Eliminate - unproven effectiveness for the treatment of inorganic compounds and inappropriate for low concentrations.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (Continued)	Physical (Continued)	Sedimentation	Separation of solids from water via gravity settling.	Retain as a pretreatment step prior to potential treatment processes.
	Chemical	Ion Exchange	Process in which ions, held by electrostatic forces to charged functional groups on the resin surface, are exchanged for ions of similar charge in a water stream.	Retain for the removal of low concentrations of dissolved vanadium.
		Reduction	Use of reducers such as sulfur dioxide, sulfite compounds, or ferrous iron compounds to decrease the oxidation state of organic and inorganic compounds.	Eliminate – not applicable to the removal of dissolved vanadium.
		Chemical Precipitation	Use of reagents to convert soluble constituents into insoluble constituents.	Eliminate – not effective for the removal of very low concentrations of inorganic compounds.
		Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Retain as a pretreatment step prior to potential treatment processes.
		Neutralization/pH Adjustment	Use of acids or bases to counteract excess pHs.	Retain as a possible pretreatment step or final step prior to discharge.
	Biological	Aerobic	Natural degradation of organic contaminants via microorganisms in an aerobic (oxygen) environment.	Eliminate – vanadium is not amenable to biological degradation.
		Anaerobic	Natural degradation of organic contaminants via microorganisms in an anaerobic (oxygen-deficient) environment.	Eliminate – vanadium is not amenable to biological degradation.

TABLE 3-2

PRELIMINARY SCREENING OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

General Response Action	Technology	Process Options	Description	Screening Comment
Discharge/ Disposal	Surface Discharge	Direct Discharge to surface water	Discharge of treated water.	Retain for discharge of treated groundwater.
		Indirect Discharge to industrial wastewater / sewage treatment plant (IWTP/STP)	Discharge of collected/treated water to NAS Cecil Field STP or regional publicly owned treatment works (POTW) once the Base is connected.	Retain for discharge of treated groundwater.
		Off-Site Treatment Facility	Treatment and disposal of water at an off-site treatment works.	Eliminate – impractical due to large volume of treated groundwater.
	Subsurface Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge collected/treated groundwater underground.	Eliminate – groundwater is too shallow for effective discharge to surficial aquifer. No suitable area is located reasonably close to Site 45 for deep well injection.

Implementability

There would be no implementability concerns since no actions would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No Action is retained for comparison to other options.

3.5.2 Limited Action

3.5.2.1 Institutional Controls

Institutional controls would consist of limiting access to groundwater and restricting future land use. A LUCIP would be prepared and implemented, including deed restrictions to prevent Site 45 from being used in the future as a residential area and to restrict the use of the surficial aquifer groundwater. A formal notification would be issued to the St. John Water Authority not to issue permits for installation at Site 45 of wells that would draw water from the surficial aquifer.

Effectiveness

Land and groundwater use restrictions would be effective, depending on the administration of controls. These controls would minimize potential human health risks associated with exposure to contaminated groundwater.

Implementability

Institutional controls would be readily implementable. As part of change of the site from military to private ownership, provisions will be incorporated in property transfer documents to insure the continued implementation of institutional controls. Resources are readily available for the preparation of deed restrictions.

Cost

Costs of institutional controls would be low.

Conclusion

Institutional controls are retained in combination with other process options for the development of remedial alternatives.

3.5.2.2 Monitoring

Sampling and analysis of groundwater within and downgradient of the contaminant plume could be used to evaluate migration of contaminants and the potential for contamination of onsite drinking water supply and nearby residential, municipal, and commercial wells. Monitoring could also be used to monitor the progress of natural attenuation or active groundwater remediation.

Effectiveness

Monitoring would not of itself reduce the toxicity, mobility, or volume of contaminants in the groundwater but it would allow the evaluation of potential off-site migration of contaminants and the potential reduction in contaminant concentrations through natural attenuation. By serving as a warning mechanism, periodic groundwater monitoring would enable the evaluation of active remedial actions if a threat of contamination arose in the area. Monitoring would also be helpful in measuring and evaluating the effectiveness of groundwater remediation technologies.

Implementability

A groundwater monitoring program could be readily implemented at Site 45. Local and state permits would be required for monitoring well installation.

Cost

Capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained in combination with other process options for the development of remedial alternatives.

3.5.2.3 Natural Attenuation

Natural attenuation would consist of monitoring groundwater quality to determine the extent to which, if any, contaminant concentrations would be reduced over time through naturally-occurring processes, such as dispersion, dilution, or adsorption.

Effectiveness

Naturally-occurring processes are likely to reduce contaminant concentrations in the aquifer over the long term. This is evidenced by the results of the sampling and analysis of groundwater at Site 45 that show a downward trend in the detected concentrations of vanadium. Continued monitoring of vanadium concentrations within the aquifer would evaluate the effectiveness of natural attenuation.

Implementability

Natural attenuation would be easy to implement. Monitoring of groundwater quality, groundwater use restrictions, and periodic site reviews could readily be performed and the necessary resources are available to provide these services.

Cost

Capital and O&M costs for natural attenuation would be low.

Conclusion

Natural attenuation is retained in combination with other process options for the development of remedial alternatives.

3.5.3 Removal

The only technology considered under this GRA is groundwater extraction. Two methods for groundwater extraction were retained from the preliminary screening, extraction wells and collection trenches.

3.5.3.1 Extraction Wells

Wells are drilled into the aquifer and screened below the water table to access the groundwater. Pumping is used to extract the water as it collects in the wells and bring it to the surface. The process of extraction creates a hydraulic gradient, that induces further flow of groundwater into the well. Extraction wells that are placed in the path of migration of a contaminant plume can also be used to intercept and contain the plume. Extraction wells that are placed within the contaminated plume can be used to clean the aquifer by removing the contaminated groundwater and flushing the saturated zone. The flushing action occurs when the fresh water from upgradient (clean) areas replaces the extracted contaminated groundwater and causes more contaminants to desorb from the saturated zone soils. Thus, theoretically,

the saturated zone soils progressively lose contaminants until the concentrations in the groundwater are at acceptable levels. The selection of the appropriate well system depends upon the depth of contamination and the hydrologic and geologic characteristics of the aquifer.

Extraction pumps are typically submersible, electrically operated centrifugal pumps or pneumatically operated ejector pumps. For shallow groundwater extraction (depths up to 10 ft), surface pumps may be used. Centrifugal pumps are not practical for use at low extraction rates less than 1 gpm, and, in such cases, pneumatic ejector pumps are preferred.

Effectiveness

Extraction wells can be effective for intercepting and containing the migration of a contaminant plume. The location and screening depth of the wells are important criteria that must be taken into consideration in achieving adequate capture of the contaminant plume. Extraction wells are a well-established and well-proven technology for the removal of contaminated groundwater and the containment of groundwater contaminant plumes. While the initial effectiveness of this technology for contaminant capture is high, it has often been shown to decrease over time. This decrease is generally due to one or more of several factors, including the presence of preferential flow pathways due to aquifer heterogeneity, contaminant adsorption onto aquifer materials, diffusion of contaminants into the pore spaces of low-permeability materials, and creation of stagnation zones due to pumping operations. It should be noted, however, that no such decrease over time is observed in the effectiveness of this technology for containment of contaminant plumes. The effectiveness of an extraction well system depends largely on the extent of contamination and site-specific geology and hydrogeology. The use of wells to extract groundwater should reduce contaminant concentration and may attain the PRGs over the long term. This technology is reliable and minimal effects on human health and the environment would be expected during implementation.

Implementability

Extraction wells are relatively easily installed and pumps are widely available for a variety of flow rates and aquifer conditions. Implementation of this technology would require long-term O&M. Well screens require regular inspection and well flushing to remove fine-grained material that may clog the wells. Pumps also require regular preventive maintenance. Pneumatic pumps have an additional requirement of a source of compressed air and regular inspection of the pump mechanism as well as the air supply lines. Local and state permits may be required for installation of extraction wells. Extracted groundwater would require treatment prior to disposal/discharge.

Site 45 lies within a relatively congested area that will remain active. Existing structures may limit placement of wells and optimal placement may not be possible.

Cost

Capital and O&M costs of extraction wells are low.

Conclusion

Extraction wells are retained in combination with other process options for the development of remedial alternatives.

3.5.3.2 Collection Trenches

Collection trenches are used to convey and collect aqueous discharges by gravity flow. They essentially function like a line of extraction wells by creating a continuous zone of influence. Groundwater within this zone flows toward the collection points. However, trenches cannot create as steep a hydraulic gradient as extraction wells and, consequently, are less effective at depressing the water table. Since collection trenches function like a line of extraction wells, they can perform many of the same functions. They offer the advantage of being able to collect contaminated water in situations where the groundwater recharge rate is insufficient to sustain extraction well pumping.

A collection trench is formed by excavating a ditch a few feet wide to a depth where an impermeable base is encountered. A backhoe or clamshell is common equipment used for the excavation. This excavated trench is then backfilled with permeable material, such as gravel or crushed rock. Collection pipes and pumps are then placed in the trench for water removal.

Effectiveness

Collection trenches can be effective for capturing and containing a contaminant plume. Collection trenches do not generate hydraulic gradients as steep as those created by wells. Therefore, remediation of the aquifer may take more time, since the flushing action will not be as powerful. Collection trenches are also best-suited for the extraction of shallow groundwater and, although current depth of contamination does not extend beyond approximately 22.5 ft bgs, no confining layer is reached until approximately 90 ft bgs, and this technology could therefore be ineffective to prevent potential downward contaminant migration.

Implementability

Collection trenches would be relatively easy to install. However, in a congested area such as Site 45, proper placement of these trenches would be even more restricted than that of extraction wells. Soil excavated to install the trenches would have to be disposed appropriately.

Cost

Costs depend primarily on the depth of excavation, stability of soils, and groundwater flow rates. Capital costs are generally low to moderate and O&M costs are low.

Conclusion

Collection trenches are eliminated from further consideration because extraction wells would be more effective and easier to implement.

3.5.4 In-Situ Treatment

The technology considered under this GRA is a Permeable Reactive Barrier (PRB). A PRB is an emplacement of reactive materials in the subsurface designed to intercept a contaminant plume, provide a flow path through the reactive media, and transform the contaminant(s) into environmentally acceptable forms to attain remediation concentration goals downgradient of the barrier.

PRBs have been used to treat a wide-range of groundwater contaminants, including chlorinated and non-chlorinated VOCs, such as benzene, toluene, ethylbenzene, and xylenes (BTEX) and inorganic compounds, such as hexavalent chromium. Iron metal is, by far, the most common reactive medium used in PRGs for the treatment of chlorinated VOCs, such as trichloroethene (TCE). Other materials, such as amended zeolites and bentonites and GAC have been successfully used for the removal non-chlorinated VOCs, such as BTEX.

PRBs are generally built in two basic configurations: funnel-and-gate and continuous. The funnel-and-gate PRB uses impermeable walls (sheet pilings, slurry walls, etc.) as a ”funnel” to direct the contaminant plume into a “gate” containing the reactive media, whereas the continuous PRB completely intercepts the plume flow path with reactive media. Since PRBs are not designed to contain groundwater movement but to intercept groundwater contaminant, the reactive media permeability must be at least equal or greater than the permeability of the surrounding aquifer to avoid diversion of the groundwater flow path. This is particularly necessary with the funnel-and-gate design where the cross-section of the permeable zones is restricted. Because the emplacement of reactive material generally requires excavation, both types of PRBs has been typically limited to relatively shallow depths of around 50 ft bgs. However, the

use of alternate technologies, such as slurry injection and hydrofracturing, may help to overcome some of these emplacement limitations.

Effectiveness

Although the effectiveness of PRBs for the removal of such inorganic compounds as hexavalent chromium has been well documented, it is not known how well such PRBs would remove vanadium from the Site 45 groundwater.

Implementability

PRBs would be relatively easy to install to a depth of up to 50 ft bgs, that is well below the current depth of groundwater contamination. This could be accomplished with conventional or slightly modified excavation equipment and many competent contractors offer this kind of services.

However, as previously mentioned, Site 45 is situated in a relatively congested area and this would significantly impact on the proper placement and ease of construction of a PRB.

Once installed, the O&M requirements of PRBs would be minimal and would be essentially limited to the monitoring of groundwater quality to verify performance and routine inspections to verify continued integrity of the structure.

Cost

Capital cost of installation of a shallow PRB, as required at Site 45, would be low to moderate. O&M costs would be very low.

Conclusion

A PRB is eliminated from further consideration primarily because of concerns about effectiveness for the in-situ treatment of vanadium and also because of concerns about constructibility in a congested environment such as Site 45.

3.5.5 Ex-Situ Physical Treatment

3.5.5.1 Sedimentation

Sedimentation is a process that removes the suspended solids from a liquid by producing quiescent hydraulic conditions. This allows gravity to settle out the unstable solids from suspension. This

technology may be used in conjunction with precipitation. Two slightly different sedimentation options are used including clarification (to typically produce a 2 to 8 percent sludge) and thickening (to typically further concentrate clarification sludges to 8 to 15 percent).

Effectiveness

Sedimentation would not of itself be effective for the removal of COCs from groundwater at Site 45. However, this technologies would be effective for the removal of excessive concentrations of suspended solids that would otherwise undermine the efficiency of COC removal technologies such as GAC adsorption, reverse osmosis, or ion exchange. However, based on previous characterization of the groundwater at Site 45, it is unlikely that such pretreatment would be required.

Implementability

Sedimentation would be readily implementable. Numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for sedimentation would be low.

Conclusion

Sedimentation is eliminated because no high concentrations of suspended solids are anticipated in the extracted groundwater.

3.5.5.2 Filtration

Filtration is a process using a porous medium to remove solid particles from a liquid or gas. This technology is generally used as a groundwater pre-treatment to remove suspended solids before other treatment processes and/or for the final cleaning or polishing of treated effluent.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), or beds of granular material, such as sand. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Most type of liquid filters, except those utilizing disposable filter elements (such as cartridge filters) require periodic cleaning to remove the suspended solids accumulated in the filter medium and restore filtration

efficiency. This cleaning is typically performed with a countercurrent of water, or backwash, which carries away the solids retained on the filter medium.

Effectiveness

Filtration would not be expected to be effective of itself for the removal of vanadium from groundwater at Site 45. However, this technology would effectively reduce excessive concentrations of solids particles suspended in the groundwater and that might otherwise undermine the efficiency of downstream treatment technologies such as air stripping or liquid-phase GAC adsorption. Filtration would also effectively remove whatever contaminants may be adsorbed on the solid particles suspended in the groundwater. Based on previous characterization of the groundwater at Site 45, it is likely that such pretreatment would be required.

Implementability

Filtration would be readily implementable. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Liquid or solid residues resulting from the periodic cleaning or replacement of the filter medium would have to be properly disposed of.

Cost

Capital and O&M costs for filtration would be low.

Conclusion

Filtration is retained in combination with other process options for the development of remedial alternatives.

3.5.5.3 GAC Adsorption

GAC adsorption is a frequently applied technology for the removal of contaminants from air or water. GAC adsorption is principally targeted towards the removal of organic compounds and is more effective for the less polar and less soluble compounds. GAC adsorption is also sometimes used for the removal of relatively low concentrations of certain inorganic compounds. The fundamental principle behind GAC adsorption involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As the contaminated liquid or vapor passes through one or more vessels containing GAC, the contaminants are captured on the active sites

of the carbon grains and eventually occupy all of these sites. The exhausted GAC must then either be regenerated or disposed of.

Typical GAC adsorption treatment systems include atmospheric or pressurized columns operating in series and/or parallel configuration. Liquid-phase GAC columns are typically designed with backwashing capability to minimize solids fouling that would increase GAC replacement frequency. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area/volume ratio of the activated carbon, and solubility of the organic compound will affect the carbon adsorption process.

Effectiveness

Liquid- and vapor-phase GAC adsorption is a well-proven, reliable technology that would be effective for removing of many organic compounds but it is much less so for the removal of inorganic compounds, such as the vanadium contained in the Site 45 groundwater. Although GAC adsorption has been shown to be capable of removing similar inorganic compounds, such as chromium, its long-term performance has sometimes been proven to be somewhat erratic, with an unpredictable tendency towards uncontrolled release, also referred to as sloughing off, of previously-adsorbed compounds, resulting in contaminant release in the treated water.

Implementability

GAC adsorption would be readily implementable. There are a sufficient number of qualified vendors that provide GAC adsorption units. Pretreatment would be required to prevent premature carbon fouling if the groundwater to be treated has a suspended solids concentration greater than 50 mg/L, or an oil and grease concentrations greater than 10 mg/L, or calcium or magnesium concentrations greater than 500 mg/L. At Site 45, a filtration pretreatment step is likely to be required as a safeguard to ensure maximum GAC life. Spent GAC containing the concentrated contaminants would have to be regenerated, incinerated, or disposed of in a hazardous waste landfill. Thermal, steam, and solvent treatments are the most common types of GAC regeneration technologies, that are typically conducted off site. Special handling of the periodically generated backwash liquids must also be taken into account.

Cost

Capital cost for GAC adsorption would be low while O&M costs would be moderate, based upon expected GAC consumption.

Conclusion

GAC adsorption is eliminated from further consideration due to concerns regarding its effectiveness for the dependable removal of vanadium.

3.5.5.4 Reverse Osmosis

Reverse osmosis would consist of forcing the groundwater to be treated through a special membrane that allows the passage of water but retains dissolved inorganic compounds as well as certain organic compounds. Depending on the type of membrane used and pressure applied, essentially all dissolved materials can be removed from the treated groundwater. The removed compounds are concentrated into a residual or reject stream, that must be disposed.

Effectiveness

Reverse osmosis is an established process to reduce the mineralization of brackish water down to potable level and should be capable of removing the vanadium from the Site 45 groundwater. However, because reverse osmosis membranes typically lack selectivity and because vanadium constitutes such a small fraction of the total mineralization of the Site 45 groundwater, significant reduction of the vanadium concentration would require essentially complete water deionization. Reverse osmosis is not particularly well suited for this application because it would require high operating pressures and large volume of reject stream.

Implementability

Reverse osmosis would be simple to implement. The resources, equipment, and materials necessary for such an implementation are readily available. Typical systems are fully automatic and require minimum operating supervision. Maintenance would consist of periodic membrane replacement. Depending on operating pressure, the pressurizing pumps could also constitute a high-maintenance item. Since even modest concentrations of suspended solids could result in premature membrane fouling, pre-filtration is generally required. As previously mentioned, a reject stream would be generated that would have to be disposed of.

Costs

Capital and O&M costs for reverse osmosis would be moderate to high, depending on the size of the system and the required operating pressure.

Conclusion

Reverse osmosis is eliminated from further consideration because of effectiveness concerns.

3.5.6 Ex-Situ Chemical Treatment

3.5.6.1 Neutralization/pH Adjustment

Neutralization/pH adjustment is a process for achieving appropriate pH levels for removal of contaminants. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice-versa.

Effectiveness

Neutralization/pH adjustment is generally effective for the removal of certain contaminants, mostly inorganics, by bringing them out of solution. For Site 45, neutralization/pH adjustment would not of itself be effective for the removal of COCs in groundwater. However, this technology would enhance the effectiveness of such pretreatment technologies as coagulation/flocculation and sedimentation and may be required prior to discharge of treated groundwater.

Implementability

Neutralization/pH adjustment would be readily implementable. This technology is widely used and numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for neutralization/pH adjustment would be low.

Conclusion

Neutralization/pH adjustment is eliminated because the pH of the extracted groundwater is anticipated to be acceptable for discharge and pH adjustment would not be required for removing contaminants out of solution.

3.5.6.2 Coagulation/Flocculation

Coagulation/flocculation is a process that consists of adding certain chemical reagents that result in the agglomeration of small suspended solids particles into larger ones, thus increasing significantly the effectiveness of sedimentation.

Effectiveness

Coagulation/flocculation would not of itself be effective for the removal of COCs from groundwater at Site 45. However, this technology would be effective to optimize the removal of excessive concentrations of suspended solids that would otherwise undermine the efficiency of COC removal technologies such as air stripping or liquid-phase GAC adsorption. Based on previous characterization of the groundwater at Site 45, it is unlikely that such pretreatment would be required.

Implementability

Coagulation/flocculation would be readily implementable. Numerous qualified equipment vendors and contractors offer equipment and services to implement this technology.

Cost

Capital and O&M costs for coagulation/flocculation would be low.

Conclusion

Coagulation/flocculation is eliminated because no high concentrations of suspended solids are anticipated in the extracted groundwater.

3.5.6.3 Ion Exchange

Ion exchange would consist of percolating the groundwater to be treated through a bed of a special resin medium capable of capturing ions from the groundwater and exchanging these with the ions populating the active sites of the resin medium. There are two main categories of ion exchange resins, including cationic resins, with active sites populated with positive ions (cations), and anionic resins, with active sites populated with negative ions (anions).

Cationic resins are most often used with either sodium (Na^+) or hydrogen (H^+) ions populating their active sites. Anionic resins are most often used with either chloride (Cl^-) or hydroxyl (OH^-) ions populating their active sites. Once most of the original ions on the active sites have been replaced with those captured from the groundwater being treated, the ion exchange resin is said to be saturated and is temporarily taken out of service for regeneration. This regeneration consists of flushing the resin with a concentrated solution of the original ion to reverse the exchange process and repopulate the active sites with this original ion. Typically, cationic resins are regenerated with either sodium chloride, if operating in the sodium cycle, or sulfuric or hydrochloric acid, if operating in the hydrogen cycle. Anionic resins are

regenerated with sodium chloride, if operating in the chloride cycle, or with caustic soda (sodium hydroxide), if operating in the hydroxyl cycle. The regeneration process generates a waste brine residue that contains the ions removed from the treated groundwater and a surplus of the regenerating ions. This waste brine must generally be neutralized and undergo some form of treatment, such as evaporation, prior to disposal.

When the purpose of ion exchange is to lower mineralization, as is often the case with water treatment, resins are operated in the hydrogen and hydroxyl cycle. When the purpose of ion exchange is to remove one or more ionic species, as is most often the case for groundwater remediation, resins are operated in the sodium and chloride cycle. This has the advantage of not requiring the handling of hazardous liquids such as acid, caustic soda, and the waste fluids resulting from the use of these chemicals for resin regeneration.

Effectiveness

Ion exchange is a well-proven process for the removal of inorganic compounds down to extremely low concentrations. For the ex-situ treatment of the Site 45 groundwater, ion exchange would be specifically targeted to remove vanadium down to its low anticipated discharge standard of 20 µg/L. Assuming that vanadium is present in the Site 45 groundwater as a vanadyl oxide (VO^{2+}), which is the most likely form to have originated from fuel combustion emissions, the vanadium could be removed by a strong-acid type cation exchange resin operating in the sodium cycle. This would replace the vanadium with sodium.

However, it should be noted that ion exchange resins typically lacks selectivity and would not only exchange the vanadium, but also most of the non-sodium cations contained in the groundwater. Average vanadium concentration in the contaminant plume (approximately 100 µg/L) only constitutes a minute fraction of the total cationic concentration of the Site 45 groundwater (approximately 100 mg/L). Therefore, much more ion exchange resin would have to be used to treat this groundwater than would be required for the removal of vanadium alone and the resin would have to be regenerated much more frequently.

Implementability

Ion exchange would be simple to implement. Treatability testing would be required to verify that vanadium can be removed down to surface discharge limits with the use of cation exchange resin operating in the sodium cycle and to determine the operating capacity of this resin. The resources, equipment, and materials necessary for such an implementation are readily available. Typical ion exchange systems are fully automatic and require minimum operating supervision. Maintenance requirements would consist of routine inspection of the resin bed and periodic replacement of damaged or

lost resin. Since suspended solids interfere with the performance of most ion exchange resins, pretreatment would most likely be required.

As previously mentioned, the ion exchange units would have to be regularly regenerated, typically once a day, with a sodium chloride brine that would generate a waste fluid requiring off-site disposal.

Costs

Capital and O&M costs for ion exchange would be high, based upon the size of the ion exchange system required and the anticipated frequency of regeneration for the treatment of the Site 45 groundwater.

Conclusion

Ion exchange is retained in combination with other process options for the development of remedial alternatives.

3.5.7 Disposal

3.5.7.1 Direct Discharge

This technology would consist of discharging the treated (or untreated) groundwater to the NAS Cecil Field storm sewer and drainage ditch system. This system eventually discharges into Sal Taylor Creek that flows to the St. John River.

Effectiveness

Direct discharge to the storm sewer and drainage ditch system would be an effective means of disposal for groundwater at Site 45. However, the groundwater would have to undergo adequate treatment for this option to be environmentally acceptable.

Implementability

Direct discharge to the storm sewer and drainage ditch system would be implementable. Prior to discharge, groundwater would have to be treated to comply with Florida Water Quality Standards. In addition, although an actual permit would not be required, the substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit would have to be met. Monitoring of discharged water would be required to ensure that downstream areas are not adversely effected. These requirements would be implementable and the resources necessary to satisfy them are available.

Cost

Capital and O&M costs of direct discharge would be low.

Conclusion

Direct discharge is retained in combination with other process options for the development of remedial alternatives.

3.5.7.2 Indirect Discharge

This technology would consist of discharging the untreated (or treated) groundwater to the local sewage treatment plant (STP) where it would undergo either the full or incremental treatment required for discharge to Sal Taylor Creek.

Effectiveness

Indirect discharge of untreated groundwater to the local STP would probably not be an effective mean for the disposal of the Site 45 groundwater. It is unlikely that the local STP could provide the necessary vanadium removal for ultimate discharge to surface water. Indirect discharge of treated groundwater to the local STP would be effective but unnecessary since on-site treatment would already have achieved the water quality required for surface discharge.

Implementability

Indirect discharge to the local STP would be implementable. Connection to the local sanitary sewer network should not be a problem and the relatively low flow of extracted groundwater could probably be accommodated by the STP. However, discharge of untreated groundwater would require a thorough evaluation of impacts to the STP and a modification of its NPDES permit.

Cost

Capital and O&M costs for indirect discharge to a local STP would be moderate to high, depending on the distance to the STP and whether upgrading of the STP would be necessary.

Conclusion

Indirect discharge is eliminated from further consideration due to effectiveness and implementability concerns.

3.6 SELECTION OF GROUNDWATER REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

The following remediation technologies and process options are retained to develop groundwater remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- Natural Attenuation
- Groundwater Extraction
- Filtration
- Ion Exchange
- Direct Discharge

4.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

This section presents an evaluation of each remedial alternative with respect to the criteria of the NCP of 40 CFR Part 300, as revised in 1990. The criteria as required by the NCP and the relative importance of these criteria are described in the following subsections.

4.1.1 Evaluation Criteria

In accordance to the NCP (40 CFR 300.430), the following nine criteria are used for the evaluation of remedial alternatives:

- Overall Protection of Human Health and the Environment,
- Compliance with ARARs,
- Long-term Effectiveness and Permanence,
- Reduction of Toxicity, Mobility, and Volume through Treatment,
- Short-term Effectiveness,
- Implementability,
- Cost,
- State Acceptance, and
- Community Acceptance

4.1.1.1 Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and environment in both short- and long-term, from unacceptable risks posed by hazardous substances, or contaminants present at the site by eliminating, reducing, or controlling exposure to levels exceeding remediation goals. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

4.1.1.2 Compliance with ARARs

Alternatives must be assessed to determine whether they attain ARARs under Federal environmental laws and state environmental or facility siting laws. If one or more regulations that are applicable cannot be complied with, then a waiver must be invoked. Grounds for invoking a waiver would depend on the following circumstances.

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.

- Compliance will result in greater risk to human health and the environment.

- Compliance is technically impracticable from an engineering perspective.

- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.

- A state requirement has not been consistently applied, or the state has not demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state.

- For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment.

4.1.1.3 Long-term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered as appropriate include the following:

Magnitude of Residual Risk:

Risk posed by untreated waste or treatment residuals at the conclusion of remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

Adequacy and reliability of controls:

Controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste must be shown reliable. In particular, the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment for the potential need to replace technical components of the alternative such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.

4.1.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

- The treatment or recycling processes the alternative employs and the materials that they will treat.
- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled.
- The degree of expected reduction in toxicity, mobility, or volume of waste due to treatment or recycling and the specification of which reduction(s) are occurring.
- The degree to which the treatment is irreversible.
- The type and quantity of residuals that will remain following treatment considering the presistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents.
- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

4.1.1.5 Short-Term Effectiveness

The short-term impacts of the alternative shall be assessed considering the following:

- Short-term risks that might be posed to the community during implementation.
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures.
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.
- Time until protection is achieved.

4.1.1.6 Implementability

The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

- Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required obtaining any necessary approvals and permits from other agencies (for off-site actions).

- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure necessary additional resources; the availability of services and materials; and availability of prospective technologies.

4.1.1.7 Cost

Capital costs shall include both direct and indirect costs. Annual O&M costs shall be provided. A net present worth (NPW) of the capital and O&M costs shall also be provided. Typically, the cost estimate accuracy range is plus 50 percent to minus 30 percent.

4.1.1.8 State Acceptance

The state's concerns that must be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives
- State comments on ARARs or the proposed use of waivers

These concerns cannot be evaluated at this time in the FS until the state has reviewed and commented on the FS. These concerns will be discussed, to the extent possible, in the proposed plan to be issued to for public comment.

4.1.1.9 Community Acceptance

This assessment consists of responses of the community to the proposed plan. This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment can be done after comments on the proposed plan are received from the public.

4.1.2 Relative Importance of Criteria

Among the nine criteria, the threshold criteria are considered to be:

Overall Protection of Human Health and the Environment
Compliance with ARARs (excluding those that may be waived)

The threshold criteria must be satisfied in order for an alternative to be eligible for selection.

Among the remaining criteria, the following five criteria are considered to be the primary balancing criteria.

- Long-term Effectiveness and Permanence
- Reduction of Contaminant Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

The balancing criteria are used to weigh the relative merits of alternatives.

The remaining two of the nine criteria, namely: State Acceptance and Community Acceptance are considered to be modifying criteria that must be considered during remedy selection. These last two criteria can be evaluated after the document has been reviewed by the State of Florida and the proposed plan has been discussed in a public meeting. Therefore, this document addresses only seven out of the nine criteria.

4.1.3 Selection of Remedy

The selection of a remedy is a two-step process. The first step consists of identification of a preferred alternative and presentation of the alternative in a proposed plan to the community for review and comment. The preferred alternative must meet the following criteria.

- Protection of human health and the environment.
- Compliance with ARARs unless a waiver is justified.
- Cost effectiveness in protecting human health and environment and in complying with ARARs.
- Utilization of permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable.

The second step consists of the review of the comments and determination of whether or not the preferred alternative continues to be the most appropriate remedial action for the site, in consultation with the State of Florida.

4.2 ASSEMBLY AND DETAILED ANALYSIS OF SOIL ALTERNATIVES

The following alternatives for soil remediation have been developed for Site 45:

1. No Action
2. Institutional Controls and Monitoring
3. Excavation and Off-Base Treatment and Disposal

A description and detailed analysis of these alternatives are provided in the following sections.

4.2.1 Alternative 1: No Action

4.2.1.1 Description

This alternative is a "walk-away" alternative that is required under CERCLA to establish a basis for comparison with other alternatives. Under this alternative the property would be released for unrestricted use. This alternative cannot be chosen if waste remains on site.

4.2.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection of human health and the environment. The potential for direct human and ecological exposure to contaminated soil under a possible future residential land use scenario would remain, leading to unacceptable risks. The potential would also continue to exist for the undetected migration of soil COCs to groundwater.

Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs and TBCs since no action would be taken to reduce COCs concentrations. Alternative 1 would also not comply with location-specific ARARs. Action-Specific ARARs are not applicable.

Long-term Effectiveness and Permanence

Alternative 1 would have no long-term effectiveness and permanence because contaminated soil would remain on site. As there would be no institutional controls to prevent residential development, the potential would exist for future unacceptable risk to human receptors. Residential development of Site 45 could also result in unacceptable risk to a correspondingly increased population of ecological receptors from exposure to contaminated soil. Since there would be no monitoring, the possible migration of soil COCs to groundwater would not be detected. Although COCs concentrations might eventually decrease to acceptable levels through natural attenuation, no monitoring would verify this.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not reduce toxicity, mobility, or volume of COCs through treatment since no treatment would occur. Some reduction of toxicity or volume might occur through natural dispersion, dilution, or other attenuation process but no monitoring would be performed to verify this.

Short-term Effectiveness

Since no action would occur, implementation of Alternative 1 would not pose a risk to onsite workers or result in adverse impact to the local community and the environment.

Alternative 1 would not achieve the RAOs and although the soil PRGs might eventually be achieved through natural attenuation, it would not be known when.

Implementability

Alternative 1 would be readily implementable since there would be nothing to implement. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable. The implementability of administrative measures is not applicable since no such measures would be taken.

Cost

There would be no costs associated with Alternative 1.

4.2.2 Alternative 2: Institutional Controls and Monitoring

4.2.2.1 Description

Alternative 2 is illustrated on Figure 4-1 and would consist of two major components: (1) institutional controls and (2) monitoring.

Component 1: Institutional Controls

Institutional controls would consist of limiting land use to industrial purpose. A LUCIP would be prepared and implemented to insure that, prior to any development at Site 45, adequate measures would be taken to minimize adverse human health and environmental effects. In particular, LUCs would prevent residential development of Site 45

Regular site inspections would be performed to verify the continued implementation of the LUCIP.

Component 2: Monitoring

Monitoring would consist of regularly checking COCs concentrations by advancing soil boring throughout the contaminated area and field testing the samples collected at various depths for organic vapor analysis (OVA). For each boring, the sample with the highest OVA reading would also be analyzed for TRPH, SVOCs, and arsenic by a fixed-base laboratory. Monitoring would also consist of collecting groundwater samples from existing and new wells within and downgradient of the contaminated soil area and analyzing these samples for TRPH, SVOCs, and arsenic.

Monitoring would be conducted for 30 years and the data would be evaluated to determine the need for additional remedial action at the site. Sampling frequency would be quarterly for the first year, semi-annual for the next two years, and annual for the remaining 27 years. Each sampling round would consist of advancing and sampling nine soil borings and sampling ten existing and one new monitoring wells. Every 5 years, site reviews would be conducted to evaluate the continued adequacy of the remedial alternative. These site reviews are required because this alternative allows contaminants to remain in soil at levels that exceed PRGs.

INSTITUTIONAL CONTROLS AND MONITORING

INSTITUTIONAL CONTROLS
- PREPARE AND IMPLEMENT A LUCIP TO PERVENT RESIDENTIAL DEVELOPMENT.
- PERFORM REGULAR SITE INSPECTIONS TO VERIFY CONTINUED IMPLEMENTATION OF THE LUCIP.

→

- COLLECT 6 SOIL SAMPLES PER YEAR AND ANALYZE FOR TRPH, SVOCs, AND ARSENIC.
- COLLECT GROUNDWATER SAMPLES FROM 10 EXISTING & 1 NEW WELL AND ANALYZE FOR TRPH, PAHs, AND ARSENIC.

→

PERFORM 5-YEAR SITE REVIEWS.

NOTES

LUCIP	LAND USE CONTROL IMPLEMENTATION PLAN
PAH	POLYNUCLEAR AROMATIC HYDROCARBON
SVOC	SEMIVOLATILE ORGANIC COMPOUND
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBON

DRAWN BY HJP DATE 6/6/01	BLOCK FLOW DIAGRAM SOIL ALTERNATIVE 2 OU11, SITE 45 FS NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NO. 0039
CHECKED BY DATE		APPROVED BY DATE
COST/SCHED-AREA		APPROVED BY DATE
SCALE NOT TO SCALE		DRAWING NO. FIGURE 4-1 REV. 0

As part of the change of Site 45 from military to private ownership, provisions will be incorporated into the property transfer documents to ensure continuation of the above-described monitoring.

4.2.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health and the environment.

Institutional controls restricting Site 45 to industrial use would be protective of human health by preventing unacceptable risks to future residents from direct exposure to contaminated soil.

Monitoring would be protective of the environment by detecting the potential migration of soil COCs to the groundwater.

Compliance with ARARs and TBCs

In the short-term, Alternative 2 would not comply with chemical-specific ARARs and TBCs since COCs concentrations would not actively be reduced. However, monitoring would determine whether any contaminated reduction is occurring through natural processes. Alternative 2 would comply with all location and action-specific ARARs and TBCs.

Long-term Effectiveness and Permanence

Alternative 2 would provide long-term effectiveness and permanence. Although soil COCs concentrations would not be actively reduced, risks to human health and the environment would be minimized through land use restrictions and monitoring.

Restricting Site 45 to industrial use would effectively and permanently prevent its development as a residential area, thereby preventing unacceptable risk from direct exposure of future residents and of an increased ecological population to contaminated soil.

Long-term monitoring would effectively detect potential migration of soil COCs to the groundwater and determine whether any contaminant reduction is occurring as a result of natural processes.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would not reduce toxicity, mobility, or volume of contaminants through treatment since no treatment would occur. Some reduction in toxicity and volume might occur through natural attenuation and this would be determined through monitoring.

Short-term Effectiveness

Alternative 2 would have minimal short-term effectiveness concerns. Any exposure of workers to contaminated soil during the collection of soil samples and the maintenance and sampling of existing monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Implementation of institutional controls and monitoring would not adversely impact the surrounding community or the environment.

The RAOs would be achieved immediately upon implementation of institutional controls and monitoring. Eventual attainment of PRGs through natural attenuation would be determined through monitoring.

Implementability

Alternative 2 would be readily implementable.

Maintenance of existing monitoring wells, sampling and analysis of soil and groundwater, and performance of regular site inspections and five-year reviews could readily be accomplished. The resources, equipment, and materials required for these activities are readily available.

The administrative aspects of Alternative 2 would be relatively simple to implement. No construction permit would be required for this alternative. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of land use restrictions and monitoring.

Cost

The estimated costs for Alternative 2 are as follows. These costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates:

- Capital Cost: $ 25,000
- 30-Year NPW of O&M Cost: $161,000
- 30-Year NPW: $186,000

A detailed cost estimate for this alternative is provided in Appendix C.

4.2.3 Alternative 3: Excavation and Off-Base Treatment and Disposal

4.2.3.1 Description

Alternative 3 is illustrated on Figure 4-2 and would consist of two major components: (1) excavation and (2) off-base transportation, treatment, and disposal.

Component 1: Excavation

Soil contaminated with concentrations of COCs in excess of the FDEP SCTLs for direct residential exposure (for BaPEq and TRPH) or IBDS (for arsenic) would be excavated. Pre-excavation sampling would be conducted in order to verify the exact extent of the contamination.

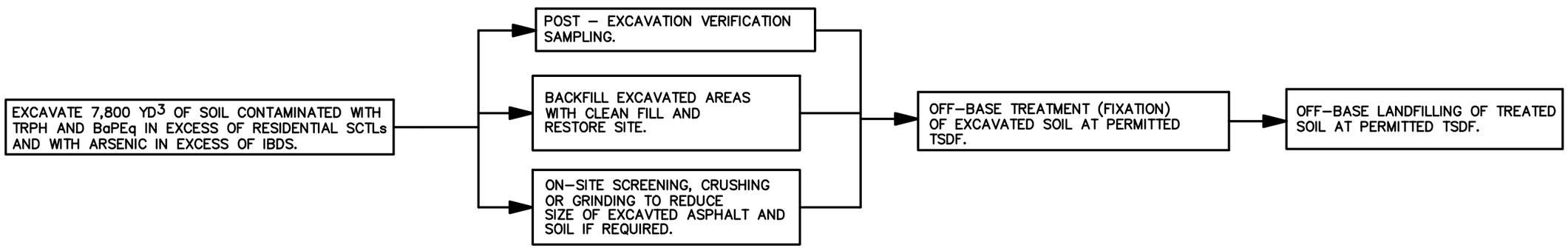
An area approximately 2.8 acres in size as shown on Figure 2-1 would be excavated down to 2 ft bgs. Taking into consideration existing buildings, this corresponds to a volume of approximately 7,800 yd^3 of excavated material. After completion of excavation, the sidewalls and the bottom of the excavated areas would be sampled and analyzed to confirm that the PRGs have been met. Following excavation, the excavated areas would be backfilled with clean fill and graded and the site would be restored to pre-excavation conditions. Since approximately one acre of the excavated area consist of paved parking lots, it is assumed that on-site screening/crushing/grinding would be required to reduce the particle size of at least part of the excavated material to less than 3-inch, as typically required by TSDFs.

Component 2: Off-Base Transportation and Treatment and Disposal

The excavated soil would be transported to an off-base permitted TSDF for treatment and disposal. The exact nature and extent of treatment would be determined by the TSDF based upon actual analysis of the contaminated soil and the requirements of their permit. It is assumed that soil with higher concentrations of TRPH and BaPEq would be treated with LTTD while soil with higher concentrations of arsenic would be chemically fixated and solidified. A certain portion of the soil might require both treatments while another portion might not require any treatment prior to disposal. As may be required by the TSDF, bench-scale treatability tests would be performed to determine optimum treatment.

The treated soil would then be disposed of. It is assumed that the treated soil would be non-hazardous and would be disposed of in a RCRA Subtitle D type landfill. Samples of the treated soil would be collected and analyzed to ensure that the soil complies with the TSDF landfill permit.

EXCAVATION AND OFF-BASE TREATMENT & DISPOSAL



NOTES

BaPEq	BENZO (a) PYRENE EQUIVALENT
IBDS	NAS CECIL FIELD SITE-SPECIFIC INORGANIC BACKGROUND DATA SET
LTTD	LOW-TEMPERATURE THERMAL DESORPTION
SCTL	SOIL CLEANUP TARGET LEVEL
TRPH	TOTAL RECOVERABLE PETROLEUM HYDROCARBON
TSDF	TREATMENT-STORAGE AND DISPOSAL FACILITY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/6/01
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

BLOCK FLOW DIAGRAM
SOIL ALTERNATIVE 3
OU11, SITE 45 FS
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-2
REV. 1

4.2.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment.

Excavation of soil with concentrations of COCs in excess of the FDEP SCTLs for direct residential exposure or IBDS would eliminate the potential for unacceptable human health risk in case of residential development of the site. Excavation of contaminated soil would also minimize the potential for soil COCs to migrate to the groundwater.

Off-base treatment and disposal of the excavated soil at a permitted TSDF would protect human health and the environment.

Some short-term risks could be incurred by workers from exposure to contaminated soil and thermal desorption offgas during on site remedial activities. However, the potential for exposure would be minimized by the implementation of engineering controls (e.g., dust suppression, offgas treatment), the wearing of appropriate PPE, and compliance with OSHA regulations and site-specific health and safety procedures. Potential negative short-term impacts to the surrounding community and environment from fugitive emissions and/or spillage of contaminated soil could be minimized through the implementation of appropriate engineering controls (e.g., offgas treatment, perimeter air monitoring, spill prevention procedures, etc.).

Compliance with ARARs and TBCs

Alternative 3 would comply with the chemical-, location-, and action-specific ARARs and TBCs.

Long-term Effectiveness and Permanence

Alternative 3 would provide long-term effectiveness and permanence.

Excavation of soil with COCs concentrations in excess of the FDEP SCTLs for direct residential exposure would effectively eliminate the potential for unacceptable human health risk in case of residential development of the site. Excavation would also effectively minimize the potential for COCs migration from soil to groundwater. Off-base treatment and disposal would effectively minimize the adverse impact from contaminated soil on human health and the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 would reduce toxicity, mobility, and volume of contaminants through treatment. Approximately 7,800 yd^3 of contaminated soil containing an estimated 1,604 pounds of COCs (1,560 pounds TRPH, 39 pounds arsenic, 5 pounds BaPEq) would be removed from Site 45 by this alternative. Toxicity and mobility of COCs would be reduced in that portion of the excavated soil that would be treated by LTTD and mobility of COCs would be reduced in that portion of the soil that would be treated by chemical fixation/solidification.

Short-term Effectiveness

Implementation of the excavation and off-base treatment and disposal components of Alternative 3, could expose construction workers to contaminated soil. This potential for exposure would be minimized by the implementation of engineering controls, such as dust suppression, and air quality monitoring. The potential for worker exposure would be further reduced by the wearing of appropriate PPE, and compliance with applicable OSHA regulations and proper site-specific health and safety procedures.

Implementation of the excavation, and off-site treatment and disposal components is not expected to adversely impact either the surrounding community or the environment. However, measures such as spill prevention and containment, erosion and sedimentation control, perimeter air monitoring, and traffic control would be taken to insure that the impact remains acceptable.

Alternative 3 could be completed in approximately 2 months and would achieve the RAOs and attain the soil PRGs at completion.

Implementability

Alternative 3 would be easily implementable.

The excavation component of this alternative could be performed with normal construction equipment, resources, equipment, and materials that would be readily available for this purpose. Since the excavation would be limited to 2 ft bgs, the need for shoring and dewatering would be minimal, although care would have to be taken not to undermine the foundations of existing buildings. Other existing site structures such as parking lots and utility lines would need to be removed or moved and restored or replaced after excavation.

Permitted TSDFs with soil treatment and non-hazardous landfilling capabilities are available which would make implementation of this alternative relatively easy.

The administrative aspects of Alternative 3 would be relatively simple to implement. A construction permit would have to be obtained and the off-site transportation and disposal of the excavated soil would require the completion of relatively numerous administrative procedures which, while constituting a significant effort, could readily be accomplished.

Cost

The estimated costs for Alternative 3 are:

- Capital Cost: $3,900,000
- NPW of O&M Cost: $0
- NPW: $3,900,000

A detailed cost estimate for this alternative is provided in Appendix C.

4.3 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

Based on the technology screening presented in Section 3.2, the following three remedial alternatives were developed.

- Alternative 1: No Action
- Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring
- Alternative 3: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring

Alternative 1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative 2 was formulated and analyzed to evaluate the adequacy of minimal action. Alternative 3 was formulated and analyzed to evaluate active remediation of the contaminant plume. A description and detailed analysis of these alternatives are presented in the following sections.

4.3.1 Alternative 1: No Action

4.3.1.1 Description

The No Action alternative maintains the site as is. This alternative does not address the groundwater contamination and is retained to provide a baseline for comparison to other alternatives. There would be no reduction in toxicity, mobility, or volume of the contaminants other than what would result from natural

dispersion, dilution, biodegradation, and other attenuating factors. Existing monitoring programs and institutional controls would be discontinued, and the site would be available for unrestricted use.

4.3.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection of human health and the environment. Under the current industrial land use, the potential for unacceptable risks to human health from exposure to contaminated groundwater would remain. In addition, under this alternative, Site 45 could be developed for residential use and this might result in unacceptable risk to human receptors and to an increased ecological population because of exposure to contaminated soil. Vanadium contamination in the groundwater might migrate and, although this migration would not have an immediate negative impact since Site 45 is located far from any surface water body, such a negative impact could eventually develop. Since no monitoring would be performed, potential vanadium migration would not be detected.

Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs or TBCs (Safe Drinking Water Act, CSF, RfDs, and Contaminant Cleanup Target Levels) since no action would be taken to reduce contaminant concentrations. Compliance with location-specific ARARs or TBCs would be purely incidental. Action-specific ARARs or TBCs are not applicable.

Long-term Effectiveness and Permanence

Alternative 1 would have no long-term effectiveness and permanence because contaminated groundwater would remain on site. As there would be no institutional controls to restrict the use of the surficial aquifer groundwater or prevent residential development, the potential would also exist for unacceptable risk to develop for human receptors and for an increased ecological population. Since there would be no groundwater monitoring, potential contaminant migration would not be detected. Although contaminant concentrations might eventually decrease to acceptable levels through natural attenuation, no monitoring would verify this.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not reduce toxicity, mobility, or volume of contaminants through treatment since no treatment would occur. Some reduction of contaminant toxicity or volume might occur through natural dispersion, dilution, or other attenuation process but no monitoring would be performed to verify this.

Short-term Effectiveness

Since no action would occur, implementation of Alternative 1 would not pose any risks to onsite workers or result in short-term adverse impact to the local community and the environment. Alternative 1 would never achieve the RAO and, although the vanadium PRG might eventually be achieved through Natural Attenuation, it would never be known when.

Implementability

Since no action would occur, Alternative 1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable. Implementability of administrative measures is not applicable since no such measures would be taken.

Cost

There would be no costs associated with the no-action alternative.

4.3.2 Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring

4.3.2.1 Description

Alternative 2 is illustrated on Figure 4-3 and would consist of three major components: (1) natural attenuation, (2) institutional controls, and (3) monitoring.

Component 2: Natural Attenuation

Natural attenuation would rely on naturally occurring processes within the aquifer to reduce the concentration of vanadium. Dispersion and dilution through aquifer movement and adsorption on soil particles would be mainly be responsible for this. Aquifer conditions would be continually monitored to ensure that concentrations are being adequately reduced through natural processes.

Component 3: Institutional Controls

Institutional controls would include limitation of land use to industrial purposes and prohibition of surficial aquifer use. These controls would eliminate or reduce pathways of exposure to contaminated groundwater. A LUCIP, including deed restrictions, would be prepared and implemented to insure that, prior to any future development at Site 45, adequate measures would be taken to minimize adverse human health and environmental effects. In particular, LUCs and deed restrictions would prevent future residential development of Site 45.

ACAD: 0039CF26.dwg 07/17/01 HJP

NATURAL ATTENUATION, INSTITUTIONAL CONTROLS, AND MONITORING

INSTITUTIONAL CONTROLS
- PREPARE AND IMPLEMENT A LUCIP TO PREVENT RESIDENTIAL DEVELOPMENT AND RESTRICT USE OF SURFICIAL AQUIFER GROUNDWATER
- PERFORM REGULAR SITE INSPECTIONS TO VERIFY CONTINUED IMPLEMENTATION OF THE LUCIP

→

COLLECT GROUNDWATER SAMPLES FROM 10 EXISTING & 1 NEW WELL AND ANALYZE FOR VANADIUM:
* QUARTERLY FOR 1 YEAR
* SEMI-ANNUALLY FOR 2 YEARS
* ANNUALLY THEREAFTER

→

PERFORM 5-YEAR REVIEWS

NOTE

LUCIP LAND USE CONTROL IMPLEMENTATION PLAN

DRAWN BY HJP DATE 11/30/00		CONTRACT NO. 0039	
CHECKED BY DATE	BLOCK FLOW DIAGRAM GROUNDWATER ALTERNATIVE 2 OU11, SITE 45 FS NAS CECIL FIELD JACKSONVILLE, FLORIDA	APPROVED BY DATE	
COST/SCHED-AREA		APPROVED BY DATE	
SCALE NOT TO SCALE		DRAWING NO. FIGURE 4-3	REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98

Use of groundwater would be controlled through deed restrictions and formal notice would be issued to the St. John Water Authority not to issue permits for installation at Site 45 of wells that would draw water from the surficial aquifer.

Regular site inspections would be performed to verify the continued implementation of the LUCIP.

Component 4: Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples both from within the contaminant plume to assess natural attenuation and downgradient of the leading edge of the plume to evaluate contaminant migration.

Monitoring would consist of collecting samples from ten existing and one new monitoring wells and analyzing them for vanadium. Monitoring would be performed for a period of 30 years. Sampling frequency would be quarterly for the first year, semi-annual for the next 2 years, and annual thereafter.

Every 5 years, site reviews would be conducted to evaluate the continued adequacy of the remedial alternative.

4.3.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 2 would be protective of human health and the environment.

Although the contaminant plume might expand, natural attenuation would eventually reduce vanadium concentration at Site 45 to below its PRG of 49 µg/L. If the results of the monitoring conducted as part of this alternative indicate otherwise and that contaminant plume expansion could have a negative environmental impact, contingency remedies would be implemented to prevent such an occurrence.

Institutional controls would be protective of human health and the environment. Restricting Site 45 to industrial use and preventing the use of surficial aquifer groundwater would be protective of human health by preventing unacceptable risks from exposure to contaminated soil and groundwater.

Monitoring would be protective of the environment by evaluating the progress of remediation and detecting potential migration of contaminated groundwater so that appropriate contingency measures can be taken, if required.

Some short-term risks could be incurred by worker from exposure to contamination during implementation of this alternative. However, the potential for such exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures.

No adverse short-term or cross-media effects are anticipated as a result of implementing this alternative.

Compliance with ARARs and TBCs

Alternative 2 would comply with location-, and action-specific ARARs and TBCs. In the short-term, this alternative would not comply with chemical-specific ARARs, such as the FDEP GCTLs but, eventually, compliance would be achieved as natural processes within the aquifer reduce vanadium concentration and this would be verified through monitoring.

Long-term Effectiveness and Permanence

Alternative 2 would provide long-term effectiveness and permanence. Although no removal of contaminated groundwater would occur and the contaminant plume might expand, risks to human health and the environment would be monitored.

Naturally-occurring processes, such as dispersion, dilution, and adsorption, would reduce vanadium concentrations in the aquifer over the long term to a level that comply with its FDEP GCTL. However, it would be some time before these processes achieve the vanadium PRG and risk from exposure to contaminated groundwater would be addressed through institutional controls.

Groundwater use restrictions would effectively prevent the use of the surficial aquifer until the vanadium PRG has been achieved. Restricting Site 45 to industrial use would effectively and permanently prevents its development as a residential area, thereby avoiding unacceptable risk of exposure for future residents and an increased ecological population.

Long-term monitoring would be an effective means to evaluate the progress of natural attenuation and detect the potential migration of contaminated groundwater.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although no active treatment is included in this alternative, contaminant volume and toxicity would be reduced over time through natural degradation processes. This alternative would not provide an immediate reduction in contaminant mobility since no groundwater containment or extraction is proposed.

This alternative would not increase the rate of natural transformation processes that reduce the toxicity, mobility, or volume of vanadium in groundwater. Human health toxicity posed by ingestion of vanadium in groundwater would remain until its concentration has been sufficiently reduced by natural processes. No treatment residuals would be produced if this alternative were implemented.

Short-term Effectiveness

Alternative 2 would have minimal short-term effectiveness concerns. Exposure of workers to contamination during the maintenance and sampling of monitoring wells would be minimized by wearing of appropriate PPE and complying with site-specific health and safety procedures. Alternative 2 would also not adversely impact the surrounding community or the environment.

The RAO would be achieved immediately upon implementation of institutional controls and monitoring. Based upon the results of the preliminary modeling presented in Appendix B, it is estimated that Alternative 2 would meet the groundwater PRG for vanadium through natural attenuation within approximately 900 to 1,300 years. As additional site-specific data becomes available the modeling can be further refined and the range of remedial duration narrowed.

Implementability

Alternative 2 would be readily implementable.

Maintenance of existing monitoring wells, sampling and analysis of groundwater, and performance of regular site inspections and 5-year reviews could readily be accomplished. The resources, equipment, and materials required to implement these activities are readily available.

The administrative aspects of Alternative 2 would be relatively simple to implement. No construction permits would be required for this alternative. As part of the change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of land and aquifer use restrictions and monitoring.

Cost

The estimated costs for Alternative 2 are:

- Capital Cost: $25,000
- 30-Year NPW of O&M Costs: $122,000
- 30-Year NPW: $147,000

The above figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. A detailed breakdown of the cost estimate for this alternative is provided in Appendix C.

4.3.3 Alternative 3: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring

4.3.3.1 Description

Alternative 3 is illustrated on Figure 4-4 and would consist of five major components: (1) groundwater extraction, (2) on-site treatment, (3) discharge to surface water, (4) monitoring, and (5) institutional controls. A typical process flow diagram (PFD) for components (1) and (2) is shown on Figure 4-5.

Component 1: Groundwater Extraction

This component would consist of installing groundwater extraction wells and operating these wells for a period of 18 years. Conceptual design calculations for this component are provided in Appendix A.

Based upon analysis of the known hydrogeological characteristics of Site 45, the groundwater extraction system would consist of four wells (EW-1 to EW-4) as shown on Figure 4-6. Each extraction well would be screened from approximately 5 to 35 ft bgs and would pump at the rate of 5 gallons per minute (gpm), for an overall groundwater extraction rate of 20 gpm.

A submersible centrifugal pump equipped with level controls would be installed in each groundwater extraction well. Each of these pumps would be connected to a piping network that would convey the extracted groundwater to an on-site treatment system.

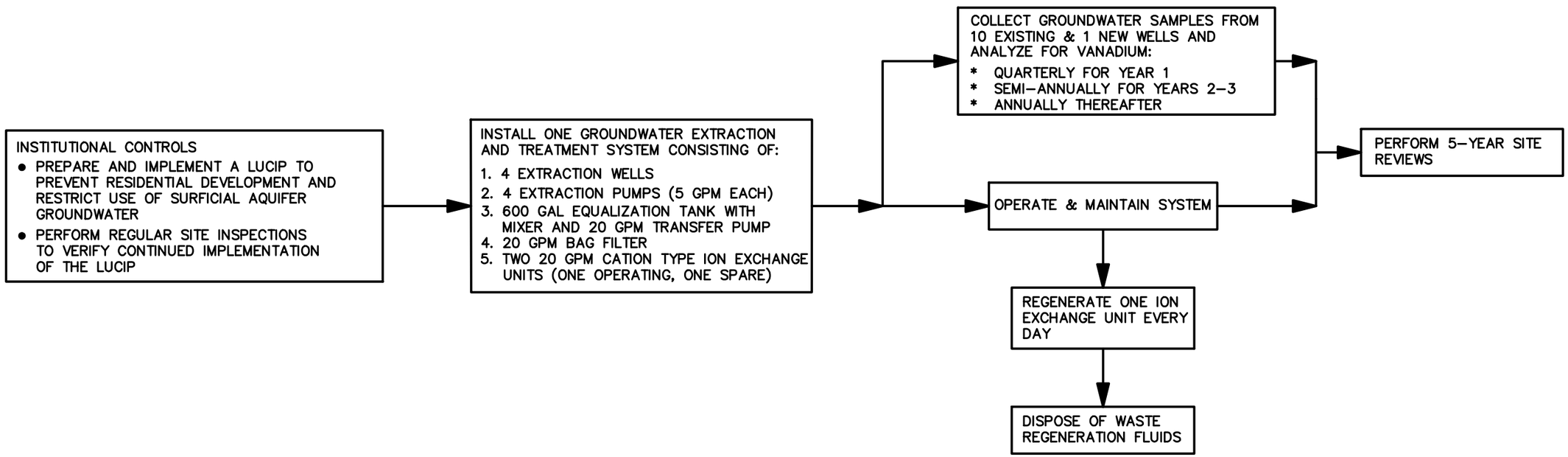
Component 2: On-Site Treatment

This component would consist of installing an on-site treatment system and operating this system for a period of 18 years. The groundwater treatment system would be housed in a 500-square-foot pre-engineered and pre-fabricated building and would consist of the following sequence of unit processes:

- Equalization
- Filtration
- Ion exchange

The design flow of the treatment system would be 20 gpm. Conceptual design calculations for the groundwater treatment system are provided in Appendix A. A treatability study would be performed to

EXTRACTION, ON-SITE TREATMENT, SURFACE DISCHARGE INSTITUTIONAL CONTORLS, AND MONITORING



NOTES

GPM GALLON PER MINUTE

LUCIP LAND USE CONTROL IMPLEMENTATION PLAN

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 6/6/01

CHECKED BY DATE

COST/SCHED-AREA

SCALE NOT TO SCALE

BLOCK FLOW DIAGRAM
GROUNDWATER ALTERNATIVE 3
OU11, SITE 45 FS
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO. 0039

APPROVED BY DATE

APPROVED BY DATE

DRAWING NO. FIGURE 4-4

REV. 2

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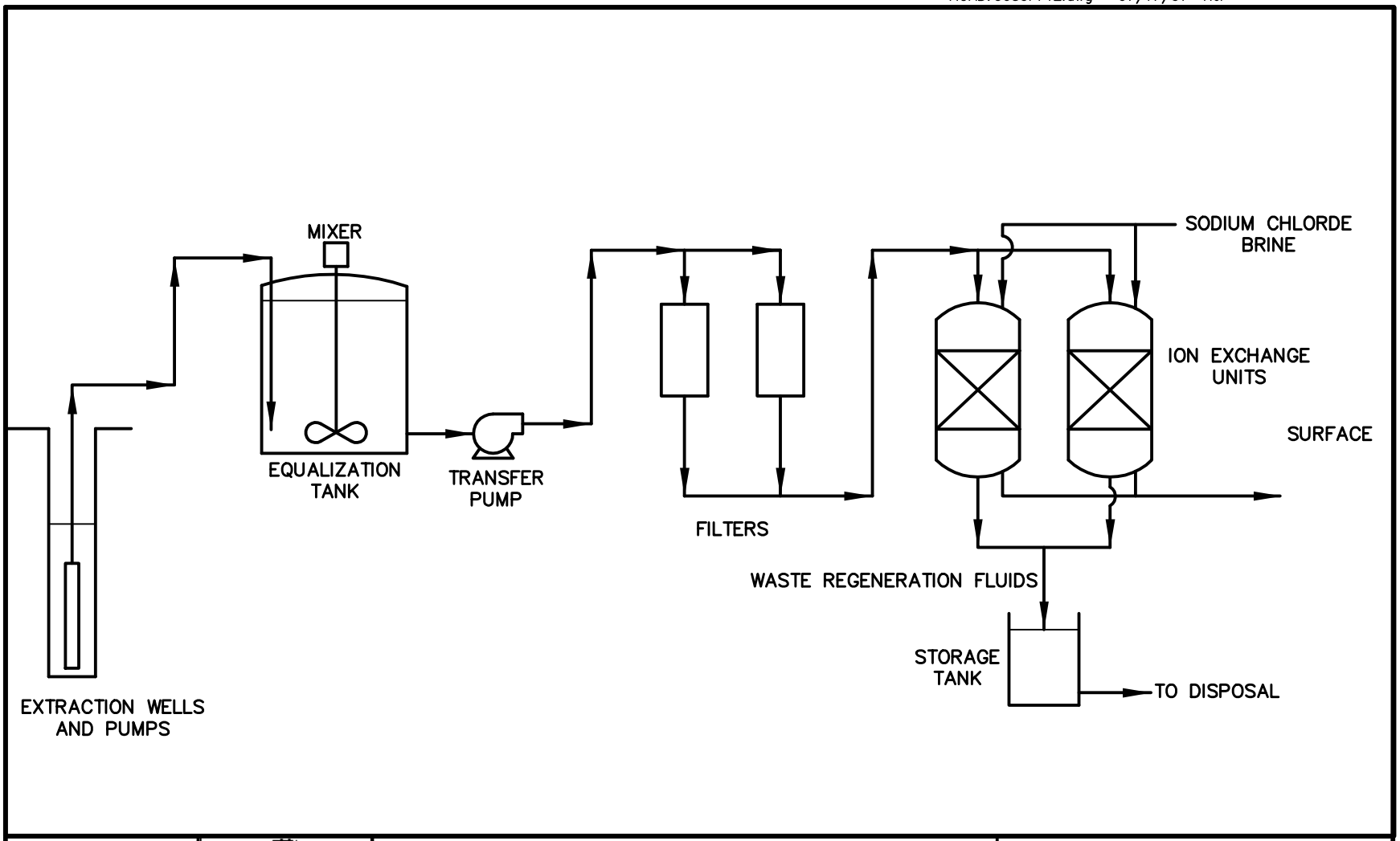
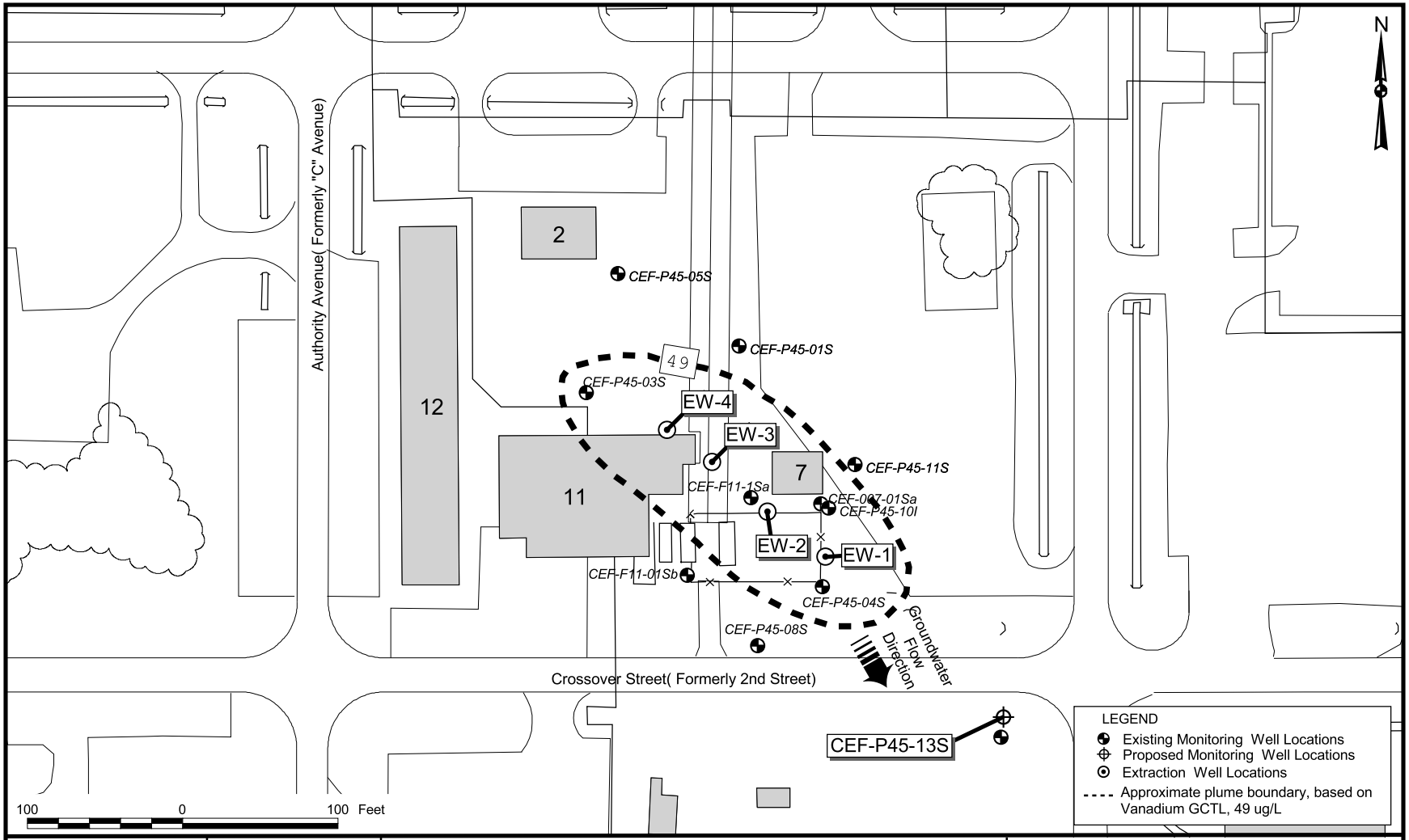


DRAWN BY HJP DATE 6/6/01	PROCESS FLOW DIAGRAM TYPICAL GROUNDWATER EXTRACTION & TREATMENT SYSTEM GROUNDWATER ALTERNATIVE 3 – OU11, SITE 45 FS NAS CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NO. 0039	
CHECKED BY DATE		APPROVED BY DATE	
COST/SCHED–AREA		APPROVED BY DATE	
SCALE NOT TO SCALE		DRAWING NO. FIGURE 4–5	REV. 1

FORM CADD NO. SDIV_AH.DWG - REV 0 - 1/20/98



DRAWN BY MJJ	DATE 12Dec00	GROUNDWATER EXTRACTION WELL LOCATIONS OU 11, SITE 45 FEASIBILITY STUDY REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHEDULE-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-6 / REV 0

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confirm this conceptual design, including the use of cation exchange resin operating in the sodium cycle and predicted resign exchange capacity.

The extracted groundwater would enter the treatment system through an equalization tank. The purpose of this equalization tank would be to blend the groundwater from the various extraction wells to equalize the quality of the influent to the downstream unit processes. The equalization tank could also be used to provide additional treatment, as may be required, such as pH adjustment. For this purpose, the equalization tank would be equipped with a mixer and sized at 600 gallons to provide approximately 30 minutes detention time under design flow conditions.

The equalized groundwater flow would be pumped from the equalization tank to a filter unit by one of two (one spare) 25 gpm centrifugal pumps. The purpose of this filter unit would be to remove most of the suspended solids that might be present in the groundwater at Site 45 and if not removed, could result in premature fouling of the downstream treatment unit. The filter unit would be of the pressurized type and would be equipped with multiple disposable filter elements installed in parallel to allow for continued service during the periodic replacement of a clogged element. Clogged filter elements would be disposed off site and replaced with fresh ones.

The filtered groundwater, still under pressure, would then flow to one of two ion exchange units. The purpose of these ion exchange units would be to remove vanadium down to its discharge limit of 20 µg/L. Assuming that vanadium is present in the Site 45 groundwater as a vanadyl oxide (VO^{2+}), which is the most likely form to have originated from fuel combustion emissions, the vanadium could be removed by a strong-acid type cation exchange resin operating in the sodium cycle. There would be two ion exchange units, with one operating and the other either being regenerated or standing by. Each unit would hold 15 ft^3 of strong acid-type cation resin operating in the sodium (softening) cycle. Upon exhaustion of the exchange resin, it would be regenerated with a concentrated sodium chloride solution. The anticipated regeneration frequency would be once a day and each regeneration would produce an estimated 225 gallons of waste regeneration fluid that would be high in total dissolved solids (approximately 25,000 mg/L). The waste regeneration fluid would be collected, temporarily stored, and disposed off site.

The treated groundwater effluent would be conveyed under residual pressure to its discharge point.

Performance of the treatment system would be monitored. Performance monitoring would consist of collecting monthly water samples from the inlet and outlet of the treatment system and analyzing these samples for vanadium and general water-quality parameters.

Component 3: Discharge to Surface Water

Treated groundwater would be discharged to the nearest storm drainage ditch. Sampling of treated groundwater would be required to satisfy the substantive requirements of an NPDES permit, as administered by the State of Florida. Sampling and analysis would be as described for treatment system performance monitoring under Component 2.

Component 4: Institutional Controls

This component would be identical to Component 3 of Alternative 2.

Component 5: Monitoring

This component would be identical to Component 4 of Alternative 2, except that monitoring would only be conducted for 18 years.

4.3.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment.

The extraction of contaminated groundwater and its treatment by use of ion exchange followed by discharge of the treated water would significantly reduce risk from exposure to vanadium in the contaminated groundwater and provide protection to future human receptors who may use this aquifer as a potable water source.

Institutional controls would be protective of human health and the environment during the remedial period until the vanadium PRG is met. Restricting Site 45 to industrial use and preventing the use of the surficial aquifer groundwater would be protective of human health and the environment by avoiding unacceptable risks of exposure to contaminated soil and groundwater.

Monitoring would be protective by evaluating the effectiveness of groundwater extraction and treatment and detecting potential migration of groundwater contaminants.

Some short-term risks could be incurred by workers from exposure to contamination during the implementation of this alternative. However, the potential for this exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures.

No adverse short-term or cross-media effects are anticipated as a result of implementing this alternative.

Compliance with ARARs and TBCs

Alternative 3 would eventually comply with chemical-specific ARARs and TBCs through a combination of groundwater extraction and treatment. Alternative 3 would also comply with location- and action-specific ARARs and TBCs.

Long-term Effectiveness and Permanence

Alternative 3 would provide long-term effectiveness and permanence.

Extraction and on-site treatment of the groundwater from the contaminant plume would effectively remove vanadium from groundwater. Groundwater extraction and treatment is a well-established remedial approach that would effectively remove vanadium-contaminated groundwater.

Groundwater use restrictions would effectively prevent the use of the surficial aquifer groundwater until the vanadium PRG is met. Restricting Site 45 to industrial use would effectively and permanently prevent its development as a residential area, thereby avoiding unacceptable risk of exposure for future residents and an increased ecological population.

Long-term monitoring would be an effective means to evaluate the progress of remediation and verify that no contaminant migration is occurring.

The controls proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 would reduce the toxicity, mobility and volume of the contaminated groundwater. The groundwater extraction and treatment system provided under this alternative is designed to remove and treat approximately 3.1 pounds of vanadium over its operating life. Disposal of the waste ion exchange regeneration fluids would ensure that the reduction in contaminant toxicity and volume is completely irreversible.

Short-term Effectiveness

Alternative 3 would reduce human health risks in the short term because groundwater use restrictions would be implemented. Exposure of workers to contamination during installation of groundwater extraction wells, construction and operation of the groundwater treatment system, and groundwater

sampling would be minimized by compliance with OSHA requirements including wearing of appropriate PPE and adherence to site-specific health and safety procedures. Implementation of institutional controls and monitoring would not adversely impact the surrounding community or the environment.

The RAO would be achieved immediately upon implementation of institutional controls and monitoring.

Based upon the results of the conceptual design calculations presented in Appendix A, it is estimated that the groundwater extraction and treatment system of Alternative 3 would reduce the vanadium concentration of the contaminant plume to its PRG of 49 µg/L within approximately 18 years.

Implementability

Alternative 3 would be readily implementable.

A treatability study would be required to confirm the effectiveness of cation exchange resin operating in the sodium cycle for the removal of vanadium and to confirm the predicted exchange capacity of the resin.

A groundwater extraction and treatment system could readily be constructed and operated without unduly restricting the ability of Site 45 to function as an active airport support area. Qualified personnel would be needed to operate and to maintain this system, but such personnel are available. Sampling and maintenance of existing monitoring wells and performance of five-year reviews could readily be accomplished. The resources, equipment, and materials required for these activities are readily available.

The surface discharge of the treated water would also be implementable. Storm sewers are located in the vicinity of Site 45 and would be available for such discharge. In order to discharge treated water to the storm sewer system, the substantive requirement of an NPDES permit would have to be met.

Treatment residuals would be produced during treatment including clogged filter elements and waste ion exchange regeneration fluids but disposal of these would be readily implementable.

The administrative aspects of Alternative 3 would be relatively simple to implement. Construction permits would be required for this alternative. As part of the change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure continued implementation of land and aquifer use restrictions and monitoring.

Cost

The estimated costs for Alternative 3 are:

- Capital Cost: $303,000
- 18-Year NPW of O&M Cost: $393,000
- 18-Year NPW: $696,000

A detailed breakdown of the cost estimate for this alternative is provided in Appendix C.

5.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section compares the analyses that were presented for each of the remedial alternatives in Section 4.0 of this FS. The criteria for comparison are identical to those used for the detailed analysis of individual alternatives.

5.1 COMPARISON OF SOIL REMEDIAL ALTERNATIVES BY CRITERIA

The following remedial alternatives for soil are being compared in this section:

- Alternative 1: No Action
- Alternative 2: Institutional Controls and Monitoring
- Alternative 3: Excavation and Off-Base Treatment and Disposal

5.1.1 Overall Protection of Health and Environment

Alternative 1 would not provide protection of human health and the environment because the potential would remain for residential development that would result in an unacceptable risk due to direct exposure of human and ecological receptors to contaminated soil. However, under industrial use, this alternative would provide adequate protection of human health and the environment. The major threat from soil contamination at Site 45 would be the migration of soil COCs to the groundwater and, since no monitoring would be performed, this migration would remain unknown.

Alternative 2 would be protective of human health and the environment. Institutional controls would provide protection by preventing residential development. Monitoring would provide protection by detecting potential migration of soil COCs to the groundwater.

Alternative 3 would be more protective than Alternative 2. Soil contaminated above PRGs would be excavated and taken to an off-base permitted TSDF for treatment and disposal.

5.1.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs as discussed in Section 4. No action-specific ARARs or TBCs apply to this alternative.

Although Alternative 2 would not comply with chemical-specific ARAR, in the short-term, monitoring would determine whether any contaminant reduction is occurring through natural processes. This alternative would comply with the location- and action-specific ARARs and TBCs.

Alternative 3 would comply with the state and Federal chemical-, location-, and action-specific ARARs and TBCs.

5.1.3 Long-term Effectiveness and Permanence

Alternative 1 would have very limited long-term effectiveness and permanence because contaminated soil would remain on site. Since there would be no institutional controls to prevent residential development, the potential would continue to exist for unacceptable risk to develop for possible future residents. Residential development at Site 45 could also result in unacceptable risk to a correspondingly increased population of ecological receptors from exposure to contaminated soil. Since there would be no monitoring, potential migration of soil COCs to groundwater would go undetected.

Alternative 2 would have long-term effectiveness and permanence. Institutional controls including prevention of residential development would effectively and permanently reduce the risk from direct exposure of human and ecological receptors to contaminated soil. Long-term monitoring would be effective for the detection of potential migration of soil COCs to the groundwater and the determination of contamination reduction through natural processes.

Alternative 3 would offer the best long-term effectiveness and permanence. Soil contaminated above the PRGs would be excavated and transported to a permitted off-base TSDF. These remedial actions would effectively and permanently eliminate the risk from direct exposure to contaminated soil and the potential for soil COCs to migrate to the groundwater.

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment. Both alternatives might achieve some reduction of contaminant toxicity and volume through natural processes but this would only be verified through the monitoring provided under Alternative 2.

Alternative 3 would best reduce contaminant toxicity, mobility, and volume through treatment. Alternative 3 would remove approximately 7,800 yd^3 of contaminated soil containing an estimated 1,604 pounds of COCs (1,560 pounds TRPH, 39 pounds arsenic, 5 pounds BaPEq). The excavation of contaminated soil at Site 45 would permanently reduce the volume of the COCs. Off-base treatment and disposal would irreversibly reduce toxicity and mobility.

5.1.5 Short-term Effectiveness

Implementation of Alternative 1 would not result in risks to site workers or adversely impact the surrounding community or environment since no remedial activities would be performed. Alternative 1 would not achieve the RAOs, although the soil PRGs might eventually be achieved over time through natural processes, this would not be verified through monitoring.

Implementation of Alternative 2 would result in a slight possibility of exposing site workers to contaminated soil during the sampling of soil and groundwater. However, the risk of exposure would be effectively controlled by wearing appropriate PPE and complying with proper site-specific health and safety procedures. Implementation of Alternative 2 would not adversely impact the surrounding community or environment. Alternative 2 would immediately achieve the RAOs and the eventual attainment of the PRGs through natural attenuation would be determined through monitoring.

Implementation of Alternative 3 would result in a significant possibility of exposing construction workers to contaminated soil during the excavation and off-base transportation, treatment, and disposal activities. However, all these risks of exposure would be effectively controlled by the implementation of engineering controls (e.g., dust suppression, offgas treatment), by the wearing of appropriate PPE, and by compliance with applicable OSHA regulations and proper site-specific health and safety procedures.

With the implementation of Alternative 3, there will be a slight risk to the surrounding community during the transportation of the contaminated soil to the off-base TSDF. This risk would be controlled through adherence to Department of Transportation (DOT) regulations and implementation of traffic control and spill prevention measures. Alternative 3 would achieve the RAO and PRGs within approximately two months.

5.1.6 Implementability

Alternative 1 would be very simple to implement since no action would occur.

Alternative 2 would be relatively easy to implement. Preparation and implementation of a LUCIP to restrict Site 45 to industrial use could be readily accomplished. Installation of new monitoring wells, maintenance and sampling of new and existing wells, and performance of five-year reviews as part of the monitoring component could also be readily accomplished. Resources, equipment, and materials are available for these tasks. The administrative implementability of institutional controls and monitoring would also be relatively easy. As part of change of the site from military to private ownership, appropriate provisions will be incorporated into the property transfer documents to ensure the continuation of these controls and monitoring.

Alternative 3 would be slightly more difficult to implement than Alternative 2. This alternative would consist of excavation and off-base treatment and disposal of contaminated soil. Off-base permitted TSDFs are available which makes the implementation of this alternative relatively easy. Alternative 3 would not require long-term monitoring. The ease of administrative implementation of Alternative 3 would be similar to that of Alternative 2, since it would also require a construction permit and, although it would not require institutional controls, it would require manifesting of the excavated soil.

5.1.7 Cost

The capital and O&M costs and NPW of the soil alternatives are as follows. Detailed cost estimates are provided in Appendix C.

Alternative	Capital ($)	NPW of O&M ($)	NPW ($)
1	0	0	0
2	25,000	122,000	147,000
3	3,900,000	0	3,900,000

5.2 SUMMARY OF COMPARATIVE ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

Table 5-1 summarizes the comparative analysis of the three soil remedial alternatives.

5.3 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES BY CRITERIA

The following remedial alternatives for groundwater are being compared in this section:

- Alternative 1: No Action
- Alternative 2: Natural Attenuation, Institutional Controls and Monitoring
- Alternative 3: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring

5.3.1 Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection of human health and the environment because contaminants would remain in groundwater and potential use of surficial aquifer groundwater and future residential development could result in unacceptable risk to human and ecological receptors. Also, under this alternative, no warning would be provided of the potential for migration of vanadium in groundwater since no monitoring would occur.

TABLE 5-1

SUMMARY OF COMPARATIVE ANALYSIS OF SOIL REMEDIAL ALTERNATIVES
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Treatment and Disposal
Overall Protection of Human Health and Environment	Would not be protective because residential development could occur that would result in unacceptable risks to human and ecological receptors. The threat of soil COCs migrating to the groundwater would remain.	Would be protective of the environment by preventing residential development and detecting the migration of soil COCs.	Would be most protective by eliminating the risk of exposure to soil contaminated above SCTLs for direct residential exposure and minimizing the potential for migration of COCs to groundwater.
Compliance with ARARs and TBCs: Chemical-Specific Location-Specific Action-Specific	 Would not comply Would not comply Not applicable	 Would not comply Would comply Would comply	 Would comply Would comply Would comply
Long-Term Effectiveness and Permanence	Would have very limited long-term effectiveness and permanence since all contaminants would remain on-site. Any long-term effectiveness would not be known since monitoring would not occur.	Would be long-term effective and permanent. The prevention of residential development through deed restrictions and the monitoring of contaminants to evaluate their migration would provide long-term effectiveness and permanence.	Would provide the most long-term effectiveness and permanence. Risks from exposure to soil contaminated above the SCTLs for direct residential exposure and from the potential migration of contaminants would be effectively and permanently eliminated through excavation, treatment, and disposal.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	Would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment but may achieve some reduction through natural processes.	Would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment but may achieve some reduction through natural processes.	Would remove 7,800 yd^3 of contaminated soil containing 1,604 pounds of COCs from the site. Treatment would reduce mobility and toxicity.

TABLE 5-1

SUMMARY OF COMPARATIVE ANALYSIS OF SOIL REMEDIAL ALTERNATIVES
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Treatment and Disposal
Short-Term Effectiveness	Would not result in short-term risks to site workers or adversely impact the surrounding community but would also not achieve RAOs through treatment.	Would result in slight risk to site workers during sampling of the soil and groundwater. This risk would be reduced through the wearing of appropriate PPE and the compliance with site-specific health and safety procedures. RAOs would be achieved immediately upon implementation. Eventual compliance with PRGs would be determined through monitoring.	Would result in a significant risk of exposure to site workers to contaminated soil during the excavation, treatment and disposal activities. This risk would be reduced through the wearing of appropriate PPE and the compliance with site-specific health and safety procedures. The RAOs would be achieved immediately upon implementation. PRGs would be attained within 2 months.
Implementability	Would be simple to implement since no action would occur.	Would be easy to implement since the resources, materials, and equipment are readily available. Provisions will be incorporated into the property transfer documents to ensure the continuation of the institutional controls and monitoring when ownership of the site was transferred to the private sector.	Would be the most difficult to implement since contaminated soil would have to be excavated and transported off-base for treatment and disposal. No institutional controls or monitoring would be required. A construction permit and manifesting would also be required.
Costs: Capital NPW of O&M NPW	 $0 $0 $0	 $25,000 $122,000 $147,000	 $3,900,000 $0 $3,900,000

Alternatives 2 and 3 would be protective of human health and the environment.

The institutional controls component of these alternatives would be protective of human health and the environment as it would reduce exposure to contaminated groundwater by preventing use of the surficial aquifer groundwater at Site 45.

The monitoring component of these alternatives would be protective of human health and the environment by evaluating the progress of remediation and detecting potential migration of contaminated groundwater so that appropriate contingency measures can be taken.

Although Alternative 2 would allow the contaminated plume to continue expanding, it would be protective of human health and the environment since natural attenuation would eventually reduce the concentration of vanadium to its PRG over time.

Alternative 3 would be more protective than Alternative 2 as it would significantly accelerate the natural attenuation of vanadium through extraction and on-site treatment of contaminated groundwater.

5.3.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical- and location-specific ARARs. Action-specific ARARs or TBCs would not apply.

In the short-term, neither Alternatives 2 or 3 would comply with chemical-specific ARARs and TBCs but both would eventually achieve compliance as they attain the vanadium PRG through natural attenuation, or active remediation or a combination of both. The alternative to achieve compliance first would be Alternative 3.

5.3.3 Long-term Effectiveness and Permanence

Alternative 1 would have very limited long-term effectiveness and permanence because no contaminant removal or reduction would occur through treatment although, over time, some contaminant reduction might occur through natural attenuation. As there would be no institutional controls to limit the use of the surficial aquifer groundwater or prevent future residential development, the potential would also exist for unacceptable risk to develop due to exposure to contaminated soil and groundwater. Since there would be no monitoring, potential migration of contaminants would remain undetected.

Alternatives 2 and 3 would provide long-term effectiveness and permanence.

The institutional controls component of these alternatives would effectively prevent the use of the surficial aquifer groundwater until the vanadium PRG is met. Restricting Site 45 to industrial use would effectively and permanently prevent its development as a residential area, thereby avoiding unacceptable risk of exposure for future resident and an increased ecological population.

The long-term monitoring component of these alternatives would provide an effective means of evaluating the progress of remediation and verifying that no contaminant migration is occurring.

Alternative 2 would provide long-term effectiveness and permanence since natural attenuation would eventually reduce concentrations of vanadium in groundwater down to its PRG.

Alternative 3 would be more long-term effective and permanent than Alternative 2 since it would irreversibly remove vanadium from the contaminant plume through extraction and on-site treatment.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 would not achieve any reduction of toxicity, mobility, or volume of contaminants through treatment. Both alternatives would achieve reduction of contaminant toxicity and volume through natural attenuation, however, under Alternative 1, this reduction would neither be verified nor quantified.

Alternatives 3 would remove an estimated 3.1 pounds of vanadium from the contaminant plume through extraction and on-site treatment. This contaminant removal would be completely irreversible.

5.3.5 Short-term Effectiveness

Implementation of Alternative 1 would not result in risks to site workers or adversely impact the surrounding community or environment since no remedial activities would be performed. Alternative 1 would never achieve the RAO and although the vanadium PRGs might eventually be attained through natural processes, this would not be verified.

Implementation of Alternative 2 would result in a slight possibility of exposing site workers to contaminated groundwater during the sampling and maintenance of existing monitoring wells. However, these risks of exposure would be effectively controlled by wearing appropriate PPE and compliance with proper site-specific health and safety procedures. Implementation of Alternative 2 would not adversely impact the surrounding community or environment. Alternative 2 would achieve the RAO immediately upon implementation of institutional controls and monitoring. The vanadium PRG would be attained within an estimated 900 to 1,300 years.

Implementation of Alternative 3 would result in a possibility of exposing construction workers to contaminated groundwater during the installation of the groundwater extraction and on-site treatment system. Implementation of this alternative would also result in the possibility of exposing O&M personnel to contaminated groundwater during the operation of the on-site treatment system and the monitoring of groundwater. However, these risks of exposure would be effectively controlled by the implementation of engineering controls (e.g., dust suppression, offgas treatment), by the wearing of appropriate PPE, and by compliance with applicable OSHA regulations and proper site-specific health and safety procedures. Implementation of Alternative 3 would not adversely impact the surrounding community and environment. Alternative 3 would achieve RAO immediately upon implementation of institutional controls and monitoring. The vanadium PRG would be met within an estimated 18 years.

5.3.6 Implementability

Alternative 1 would be very simple to implement since no action would occur.

Alternatives 2 and 3 would be technically implementable.

The technical implementability of Alternative 2 would be simpler than that of Alternative 3, since it would only require implementation of the institutional controls and monitoring.

The technical implementability of Alternative 3 would be slightly more difficult than that of Alternative 2 since, in addition to institutional controls and monitoring, this alternative would require the installation and O&M of a relatively small groundwater extraction and treatment system. Although qualified personnel would be required over the long-term for the operation and maintenance of this systems, such personnel would be readily available. Discharge of the treated groundwater to surface water would also be technically simple to implement, as storms sewers are present in the immediate vicinity of Site 45, which could be used for this purpose. On-site treatment of groundwater would generate residues, including clogged filter elements and waste ion exchange unit regeneration fluids, but disposal of these materials would be reasonably easy to accomplish.

5.3.7 Cost

The capital and O&M costs and NPW of the groundwater remedial alternatives are as follows.

Alternative	Capital ($)	30-year NPW of O&M ($)	30-year NPW ($)
1	0	0	0
2	25,000	122,000	147,000
3	303,000	393,000 (18-Year)	696,000 (18-Year)

Detailed cost estimates are provided in Appendix C.

5.4 SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Table 5-2 summarizes the comparative analysis of the three groundwater remedial alternatives.

TABLE 5-2

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring	Alternative 3: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Overall Protection of Human Health and Environment	Would not be protective because there would be a continued risk from human exposure to contaminated groundwater. Also, potential contaminant migration would remain unchecked.	Would be protective by preventing risk from exposure to contaminated groundwater through institutional controls and monitoring.	Would be more protective than Alternative 2 by providing the same protective components plus elimination of risk from exposure to vanadium in groundwater through extraction and treatment of the contaminant plume.
Compliance with ARARs and TBCs: Chemical-Specific Location-Specific Action-Specific	 Would not comply Would not comply Not applicable	 Would eventually comply Would comply Would comply	 Would eventually comply Would comply Would comply
Long-Term Effectiveness and Permanence	Would not be long-term effective and permanent since contaminants would remain on-site. Any long-term effectiveness would not be known since monitoring would not occur.	Would be long-term effective and permanent. Land and groundwater use restrictions and monitoring would effectively prevent unacceptable risk from exposure to contaminated groundwater.	Would be more long-term effective and permanent than Alternative 2 since it would actively cleanup contaminated groundwater in addition to institutional controls and monitoring.
Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	Would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment but might achieve some reduction through natural processes.	Would not achieve reduction of toxicity, mobility, or volume of contaminants through treatment but would achieve some reduction through natural processes.	Would achieve reduction of contaminant toxicity, mobility, and volume through treatment.

TABLE 5-2

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES
OU 11, SITE 45 FEASIBILITY STUDY REPORT
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring	Alternative 3: Extraction, On-Site Treatment, Surface Discharge, Institutional Controls, and Monitoring
Short-Term Effectiveness	Would not result in short-term risks to site workers or adversely impact the surrounding community but would also not achieve RAO through treatment.	Would result in slight risk of exposure to site workers during sampling of groundwater. This risk would be reduced through the wearing of appropriate PPE and the compliance with site-specific health and safety procedures. RAO would be achieved immediately upon implementation. PRG would be attained within an estimated 900 to 1,300 years.	Would result in slight risk of exposure to site workers during the installation and operation of the groundwater extraction and treatment system and the sampling of groundwater. This risk would be reduced through the wearing of appropriate PPE and the compliance with site-specific health and safety procedures. RAO would be achieved immediately upon implementation. PRG would be attained within 18 years.
Implementability	Would be simple to implement since no action would occur.	Would be easy to implement. Resources, materials, and equipment are readily available. Provisions will be incorporated into the property transfer documents to ensure the continuation of the institutional controls and monitoring when ownership of the site was transferred to the private sector.	Would be slightly more difficult to implement than Alternative 2 since, in addition to institutional controls and monitoring, a groundwater extraction and treatment system would have to be installed, operated, and maintained. Provisions will be incorporated into the property transfer documents to ensure the continuation of the institutional controls and monitoring when ownership of the site was transferred to the private sector. A construction permit would be required.
Costs: Capital 30-Year NPW of O&M 30-Year NPW	 $0 $0 $0	 $25,000 $122,000 $147,000	 $303,000 $393,000 (18-Year) $696,000 (18-Year)

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APPENDIX A

CONCEPTUAL DESIGN CALCULATIONS

A.1 GROUNDWATER EXTRACTION SYSTEM DESIGN

A.2 GROUNDWATER TREATMENT SYSTEM DESIGN

A.1

GROUNDWATER EXTRACTION SYSTEM DESIGN

TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT	JOB NUMBER
NAVY - SouthDiv	0039 DS0 11E220
SUBJECT: Cecil Field, Site 45	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
JPO	PM		

Objective: Project cleanup time for Vanadium in groundwater, under active pumping scenario. Assume source has been removed.

Site Data:

Plume Width - ~110'
Length - ~260'
Thickness - ~30'
Porosity (n) - .25

Plume Volume = L x W x Th x n = 214,500 ft³

Vanadium conc. in gw - 740 ug/L (max, = C_w), 180 ug/L (avg)

GW extraction system - Ext. wells pumping at per-well Q of 5 gpm (962.55 ft³/day), installed in center area of plume to ~40' in depth.

Max. soil conc. prior to remediation - 276 mg/kg = C_s

Site-specific K_d for vanadium = C_s / C_L

C_L = leachate conc., assumed to equal max. C_w x 20 (20 is a dilution-attenuation factor for leachate dilution in gw prior to sampling - EPA default DAF is 20 for a small site).

K_d = 276/.74(20) = 18.65

Target vanadium conc. in gw - 49 ug/L.

Technical Approach:

Using pumping rate, plume volume, K_d, and avg gw conc. data calculate the number of pore volumes & time required to reach target gw conc. of 49 ug/L. See spreadsheet program for results, project graphically as needed to estimate cleanup times.

@ 5 gpm, takes ~73 yrs to reach 49 ug/L
@ 10 gpm, " " 37 yrs " " " "
@ 20 gpm, " " 18 yrs " " " "

CLIENT	JOB NUMBER
NAVY - Southdiv	0039 DSO 11E220
SUBJECT: Cecil Field, Site 45	
BASED ON	DRAWING NUMBER
BY: JPO	CHECKED BY: RM
APPROVED BY	DATE

Drawdown (s) Estimate

$$s = \frac{2.3Q}{4\pi T} \log\left(\frac{2.25Tt}{r^2 S}\right)$$

$T = 95' \times 3.8\ ft/day = 361\ ft^2/day$

$S = .25$

$r = .25'$

$t = 30$ days

$Q = 5\ gpm = 962.55\ ft^3/day$

$= 10\ \text{"} = 1925.1\ ft^3/day$

For 5 gpm, $s = 3.02'$

for 10 gpm, $s = 6.04'$

Considering plume shape, additive drawdown effects of multiple wells, & desire to minimize dewatering of aquifer, limit individual pumping rates to $\leq$ 5 gpm/well. Position wells in plume interior, within hot spot areas of contamination to magnify pore volume flushing rates in hot spots.

Pore Volume Contaminant Concentration Calculations

Chemical -		Vanadium	
Koc =	18.6	Foc =	1

Homogeneous Aquifer Flushing Rate

Pore Vol.	Cw	n	Mw	Cs	Ms	Mt
0	0.180	0.350	0.063	3.348	5.767	5.830
1	0.178	0.350	0.062	3.312	5.705	5.767
2	0.176	0.350	0.062	3.276	5.643	5.705
3	0.174	0.350	0.061	3.241	5.582	5.643
4	0.172	0.350	0.060	3.206	5.522	5.582
5	0.170	0.350	0.060	3.171	5.462	5.522
6	0.169	0.350	0.059	3.137	5.403	5.462
7	0.167	0.350	0.058	3.103	5.345	5.403
8	0.165	0.350	0.058	3.069	5.287	5.345
9	0.163	0.350	0.057	3.036	5.230	5.287
10	0.161	0.350	0.057	3.003	5.173	5.230
11	0.160	0.350	0.056	2.971	5.117	5.173
12	0.158	0.350	0.055	2.939	5.062	5.117
13	0.156	0.350	0.055	2.907	5.007	5.062
14	0.155	0.350	0.054	2.876	4.953	5.007
15	0.153	0.350	0.054	2.844	4.900	4.953
16	0.151	0.350	0.053	2.814	4.847	4.900
17	0.150	0.350	0.052	2.783	4.794	4.847
18	0.148	0.350	0.052	2.753	4.743	4.794
19	0.146	0.350	0.051	2.724	4.691	4.743
20	0.145	0.350	0.051	2.694	4.641	4.691
21	0.143	0.350	0.050	2.665	4.590	4.641
22	0.142	0.350	0.050	2.636	4.541	4.590
23	0.140	0.350	0.049	2.608	4.492	4.541
24	0.139	0.350	0.049	2.580	4.443	4.492
25	0.137	0.350	0.048	2.552	4.395	4.443

Heterogeneous Aquifer Flushing Rate

Pore Volume Exchange Rates			
K Grouping	Relative K	Fract. Of Aq. Volume	Fract. Of Total flow
1	1	0.333	0.333
2	1	0.334	0.334
3	1	0.333	0.333

Q, gpm	Q, ft3/day	Contamin. Vol., ft3	Volume, K1 Pumped	Volume, K2 Pumped	Volume, K3 Pumped	Pore volume K1	Pore volume K2	Pore volume K3	1 PV removal K1, days	1 PV removal K2, days	1 PV removal K3, days
5	962.57	214500	320.53	321.50	320.53	71428.5	71643	71428.5	222.84	222.17	222.84

Heterogeneous Aquifer Pumped/Residual Concentrations

Time Period	Span, Days	Avg pumped conc.	Avg residual GW conc.	Span, Years
1	222.84	0.178	0.178	0.61
2	445.68	0.176	0.176	1.22
3	668.53	0.174	0.174	1.83
5	1114.21	0.170	0.170	3.05
7	1559.89	0.167	0.167	4.27
9	2005.58	0.163	0.163	5.49
12	2674.10	0.158	0.158	7.32
15	3342.63	0.153	0.153	9.15
20	4456.83	0.145	0.145	12.20
25	5571.04	0.137	0.137	15.25
30	6685.25	0.130	0.130	18.30
40	8913.67	0.117	0.117	24.40
50	11142.08	0.104	0.104	30.51
70	15598.92	0.084	0.084	42.71
90	20055.75	0.068	0.068	54.91
120	26741.00	0.049	0.049	73.21
150	33426.25	0.035	0.035	91.52
180	40111.50	0.025	0.025	109.82
210	46796.75	0.018	0.018	128.12
250	55710.42	0.012	0.012	152.53
300	66852.50	0.007	0.007	183.03

Pore Volume Contaminant Concentration Calculations

Chemical -		Vanadium	
Koc =	18.6	Foc =	1

Homogeneous Aquifer Flushing Rate

Pore Vol.	Cw	n	Mw	Cs	Ms	Mt
0	0.180	0.350	0.063	3.348	5.767	5.830
1	0.178	0.350	0.062	3.312	5.705	5.767
2	0.176	0.350	0.062	3.276	5.643	5.705
3	0.174	0.350	0.061	3.241	5.582	5.643
4	0.172	0.350	0.060	3.206	5.522	5.582
5	0.170	0.350	0.060	3.171	5.462	5.522
6	0.169	0.350	0.059	3.137	5.403	5.462
7	0.167	0.350	0.058	3.103	5.345	5.403
8	0.165	0.350	0.058	3.069	5.287	5.345
9	0.163	0.350	0.057	3.036	5.230	5.287
10	0.161	0.350	0.057	3.003	5.173	5.230
11	0.160	0.350	0.056	2.971	5.117	5.173
12	0.158	0.350	0.055	2.939	5.062	5.117
13	0.156	0.350	0.055	2.907	5.007	5.062
14	0.155	0.350	0.054	2.876	4.953	5.007
15	0.153	0.350	0.054	2.844	4.900	4.953
16	0.151	0.350	0.053	2.814	4.847	4.900
17	0.150	0.350	0.052	2.783	4.794	4.847
18	0.148	0.350	0.052	2.753	4.743	4.794
19	0.146	0.350	0.051	2.724	4.691	4.743
20	0.145	0.350	0.051	2.694	4.641	4.691
21	0.143	0.350	0.050	2.665	4.590	4.641
22	0.142	0.350	0.050	2.636	4.541	4.590
23	0.140	0.350	0.049	2.608	4.492	4.541
24	0.139	0.350	0.049	2.580	4.443	4.492
25	0.137	0.350	0.048	2.552	4.395	4.443

Heterogeneous Aquifer Flushing Rate

Pore Volume Exchange Rates			
K Grouping	Relative K	Fract. Of Aq. Volume	Fract. Of Total flow
1	1	0.333	0.333
2	1	0.334	0.334
3	1	0.333	0.333

Q, gpm	Q, ft3/day	Contamin. Vol., ft3	Volume, K1 Pumped	Volume, K2 Pumped	Volume, K3 Pumped	Pore volume K1	Pore volume K2	Pore volume K3	1 PV removal K1, days	1 PV removal K2, days	1 PV removal K3, days
10	1925.13	214500	641.07	642.99	641.07	71428.5	71643	71428.5	111.42	111.09	111.42

Heterogeneous Aquifer Pumped/Residual Concentrations

Time Period	Span, Days	Avg pumped conc.	Avg residual GW conc.	Span, Years
1	111.42	0.178	0.178	0.31
2	222.84	0.176	0.176	0.61
3	334.26	0.174	0.174	0.92
5	557.10	0.170	0.170	1.53
7	779.95	0.167	0.167	2.14
9	1002.79	0.163	0.163	2.75
12	1337.05	0.158	0.158	3.66
15	1671.31	0.153	0.153	4.58
20	2228.42	0.145	0.145	6.10
25	2785.52	0.137	0.137	7.63
30	3342.63	0.130	0.130	9.15
40	4456.83	0.117	0.117	12.20
50	5571.04	0.104	0.104	15.25
70	7799.46	0.084	0.084	21.35
90	10027.88	0.068	0.068	27.45
120	13370.50	0.049	0.049	36.61
150	16713.13	0.035	0.035	45.76
180	20055.75	0.025	0.025	54.91
210	23398.38	0.018	0.018	64.06
250	27855.21	0.012	0.012	76.26
300	33426.25	0.007	0.007	91.52

Pore Volume Contaminant Concentration Calculations

Chemical -		Vanadium	
Koc =	18.6	Foc =	1

Homogeneous Aquifer Flushing Rate

Pore Vol.	Cw	n	Mw	Cs	Ms	Mt
0	0.180	0.350	0.063	3.348	5.767	5.830
1	0.178	0.350	0.062	3.312	5.705	5.767
2	0.176	0.350	0.062	3.276	5.643	5.705
3	0.174	0.350	0.061	3.241	5.582	5.643
4	0.172	0.350	0.060	3.206	5.522	5.582
.5	0.170	0.350	0.060	3.171	5.462	5.522
6	0.169	0.350	0.059	3.137	5.403	5.462
7	0.167	0.350	0.058	3.103	5.345	5.403
8	0.165	0.350	0.058	3.069	5.287	5.345
9	0.163	0.350	0.057	3.036	5.230	5.287
10	0.161	0.350	0.057	3.003	5.173	5.230
11	0.160	0.350	0.056	2.971	5.117	5.173
12	0.158	0.350	0.055	2.939	5.062	5.117
13	0.156	0.350	0.055	2.907	5.007	5.062
14	0.155	0.350	0.054	2.876	4.953	5.007
15	0.153	0.350	0.054	2.844	4.900	4.953
16	0.151	0.350	0.053	2.814	4.847	4.900
17	0.150	0.350	0.052	2.783	4.794	4.847
18	0.148	0.350	0.052	2.753	4.743	4.794
19	0.146	0.350	0.051	2.724	4.691	4.743
20	0.145	0.350	0.051	2.694	4.641	4.691
21	0.143	0.350	0.050	2.665	4.590	4.641
22	0.142	0.350	0.050	2.636	4.541	4.590
23	0.140	0.350	0.049	2.608	4.492	4.541
24	0.139	0.350	0.049	2.580	4.443	4.492
25	0.137	0.350	0.048	2.552	4.395	4.443

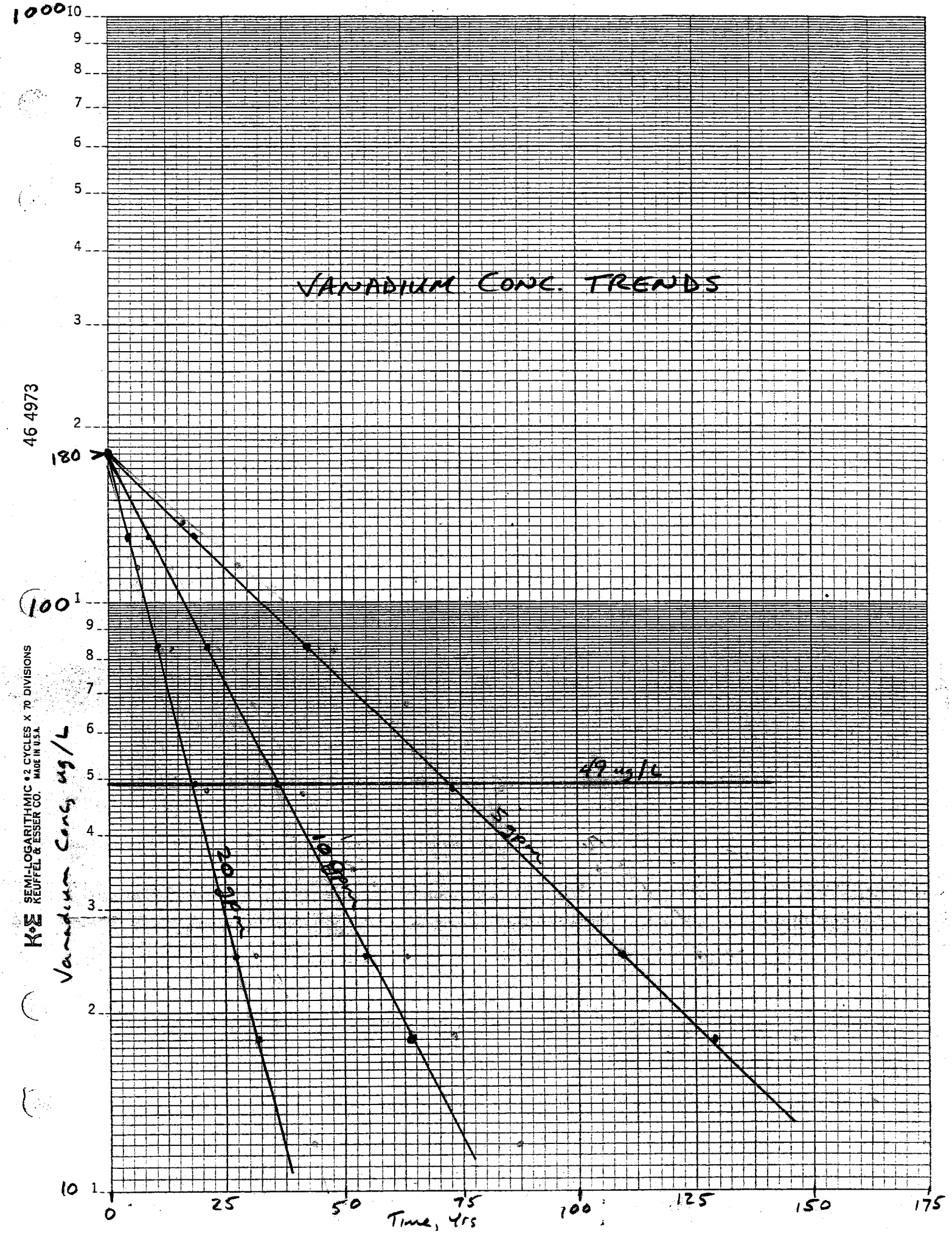
Heterogeneous Aquifer Flushing Rate

Pore Volume Exchange Rates			
K Grouping	Relative K	Fract. Of Aq. Volume	Fract. Of Total flow
1	1	0.333	0.333
2	1	0.334	0.334
3	1	0.333	0.333

Q, gpm	Q, ft3/day	Contamin. Vol., ft3	Volume, K1 Pumped	Volume, K2 Pumped	Volume, K3 Pumped	Pore volume K1	Pore volume K2	Pore volume K3	1 PV removal K1, days	1 PV removal K2, days	1 PV removal K3, days
20	3850.27	214500	1282.14	1285.99	1282.14	71428.5	71643	71428.5	55.71	55.54	55.71

Heterogeneous Aquifer Pumped/Residual Concentrations

Time Period	Span, Days	Avg pumped conc.	Avg residual GW conc.	Span, Years
1	55.71	0.178	0.178	0.15
2	111.42	0.176	0.176	0.31
3	167.13	0.174	0.174	0.46
5	278.55	0.170	0.170	0.76
7	389.97	0.167	0.167	1.07
9	501.39	0.163	0.163	1.37
12	668.53	0.158	0.158	1.83
15	835.66	0.153	0.153	2.29
20	1114.21	0.145	0.145	3.05
25	1392.76	0.137	0.137	3.81
30	1671.31	0.130	0.130	4.58
40	2228.42	0.117	0.117	6.10
50	2785.52	0.104	0.104	7.63
70	3899.73	0.084	0.084	10.68
90	5013.94	0.068	0.068	13.73
120	6685.25	0.049	0.049	18.30
150	8356.56	0.035	0.035	22.88
180	10027.88	0.025	0.025	27.45
210	11699.19	0.018	0.018	32.03
250	13927.60	0.012	0.012	38.13
300	16713.13	0.007	0.007	45.76

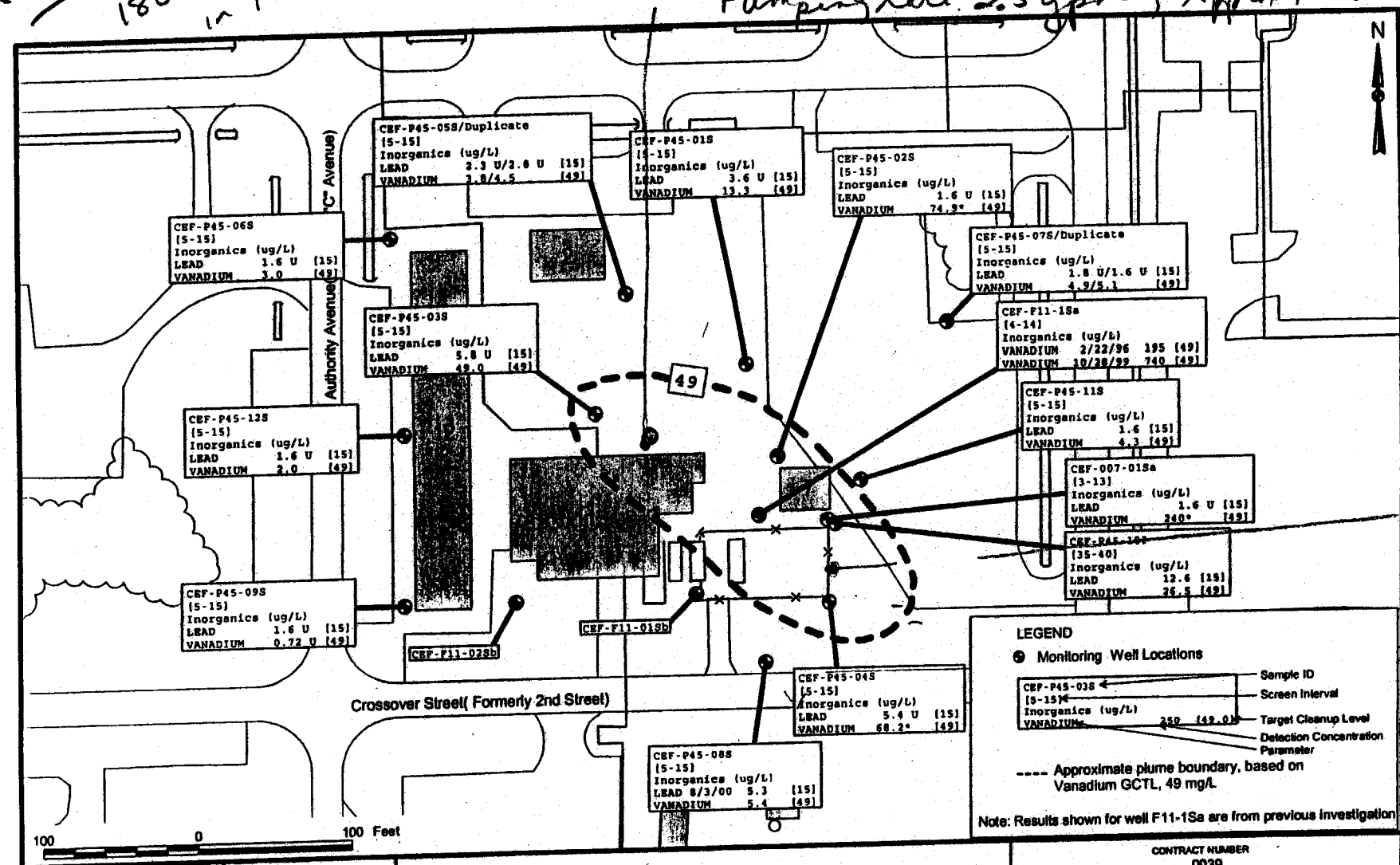

VANADIUM CONC. TRENDS
46 4973
K+E SEMI-LOGARITHMIC • 2 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
Vanadium Conc, ug/L
Time, Yrs
1000
180
100
10
49 ug/L
5 gpm
10 gpm
20 gpm
0
25
50
75
100
125
150
175

49
84.9
5+740/2
240
68.2

Avg 180 ug/L in plume

Well #1
35' deep, Screened 5-35' bgs, 6" diameter;
Pumping rate 2.5 gpm; Approx 40' SE of

CEF-P45.035



Well #2
35' deep
Screened
5-35' bgs
6" diameter
2.5 gpm
~30' S of
CEF-007-01Sa

DRAWN BY MJJ	DATE 02Oct00	GROUNDWATER RESULTS - RI SITE 45 REMEDIAL INVESTIGATION REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 5-1 / REV 0

p:\gis\NAS_CecilField\psc45_ri.apr 08Nov00 MJJ 5-1_RI Groundwater Results Layout

A.2

GROUNDWATER TREATMENT SYSTEM DESIGN

1.0 DESIGN ASSUMPTIONS

The following design assumptions are made based upon the results of the RI and previous investigations:

- The depth to which vanadium contamination exceeds the PRG (49.0 μg/L) extends to 35 ft bgs. This is based upon the facts that a vanadium concentration of 240 μg/L was detected at a depth of 15 ft bgs in well CEF-007-01Sa and a concentration of 26 μg/L was detected at 40 ft bgs in well CEF-45-10I, which is right next to well CEF-007-01Sa.
- Average vanadium concentration within the contaminant plume is approximately 230 μg/L, which is the mathematical average of the concentrations detected within the plume. Maximum vanadium concentration within the plume is 740 μg/L, as detected in well CEF-011-01Sa.

2.0 CONTAMINANT PLUME AREA AND VOLUME

Figure 1-4 shows that the surface area for the vanadium 49 μg/L isocontour, which defines the contaminant plume, is approximately 28,600 ft^2 .

Based upon a typical groundwater table depth of 5 ft bgs and on the above assumption for depth of vanadium contamination, the thickness of the contaminant plume is 30 ft (5 to 35 ft bgs).

Based on a porosity of 0.25, that is typical at NAS Cecil Field, the design volume of the contaminant plume is:

28,600 ft^2 x 30 ft x 0.25 = 214,500 ft^3 or 1,605,500 gallons.

3.0 TREATMENT SCHEME

Groundwater Alternative 3 would consist of a "pump-and-treat" system extracting and treating groundwater from the entire contaminant plume and featuring the following elements:

- Groundwater extraction wells and pumps
- Equalization
- Filtration
- Ion Exchange
- Surface Discharge

4.0 GROUNDWATER EXTRACTION WELLS AND PUMPS

As per calculations provided in Appendix A.1, the design of groundwater extraction system will consist of a total of 4 wells screened in the shallow and upper intermediate zones of the surficial aquifer and pumping 5 gpm each. System can be summarized as follows:

Well Number	Screened Depth (ft)	Pumping / Well (gpm)	Cum. Pumping (gpm)
EW-1	5-35	5	5
EW-2	5-35	5	10
EW-3	5-35	5	15
EW-4	5-35	5	20
Total			**20**

Approximate locations of extraction wells are shown on Figure 4-4. Multi-stage submersible centrifugal pumps would be installed in the above wells as follows:

Well Number	Pump Design		
	Flow Rate (gpm)	Total Discharge Head (ft)	Motor Size (HP)
EW-1	5	100	0.5
EW-2	5	100	0.5
EW-3	5	100	0.5
EW-4	5	100	0.5
Total	**20**		

Design extracted groundwater flow is 20 gpm

5.0 EQUALIZATION

Provide equalization tank to blend groundwater from various extraction wells. Equalization tank would be equipped with a mixer. Equalization tank would be sized to provide 30 minutes detention under design flow conditions.

Equalization Tank Volume: 20 gpm x 30 minutes = 600 gallons

→ Call for a 4.5-foot diameter 6 feet high equalization tank with a working capacity of 600 gallons. Tank to be of open-top cylindrical vertical configuration and manufactured of fiberglass with anti-vortex baffles.

Mixer size @ 0.5 HP/1,000 gal: 600 gallons x 0.5 HP ÷ 1,000 gallons = 0.3, say 0.5 HP

→ Call for a rim-mounted 0.5 HP high-speed propeller-type mixer.

Pumps would be provided to transfer groundwater from equalization tank to downstream treatment processes. Two transfer pumps should be provided, including an installed spare. Pump operation (start/stop) would be controlled by the liquid level in the equalization tank.

→ Call for two (one spare) horizontal-centrifugal 25 gpm equalized groundwater transfer pumps (75 ft design TDH, 1.0 HP motor).

6.0 FILTRATION

Use bag type filter unit to avoid liquid residual stream from backwashing.

Size bag filter unit for replacement of filter bag element no more frequently than once a week.

Assuming approximately 5 mg/L TSS in untreated groundwater and 90% removal, TSS accumulation in the filter within a week would be:

20 gpm x 1,440 min/day x 7 days/week x 8.34 lbs/gal x [(5 – 0.5) mg/l] x 10^{-6} = 7.57, say 8 lbs dry TSS /week

Assuming a typical solids capture capacity of approximately 1.0 lbs dry TSS per square foot of bag filter element,

required surface of bag element is:

8 lbs ÷ 1.0 lbs/ft^2 = 8 ft^2

→ Call two (one spare) multi-bag pressurized filter unit with a total filter area of 8 ft^2

7.0 ION EXCHANGE

Filtered groundwater would be treated in a pressurized reactor loaded with cation exchange resin operating in the sodium (softening) cycle and periodically regenerated with a sodium chloride (common salt) brine solution.

7.1 Groundwater Quality

Based on historical concentrations of dissolved inorganic compounds concentrations detected in filtered groundwater samples collected from wells located within the vanadium plume, the following average concentrations and ionic strength of dissolved cations would be present in the groundwater and therefore, except for sodium, be susceptible to removal by ion exchange. Only cations with an average groundwater concentration of 0.1 mg/L or more are listed. Sodium is not listed since it is not susceptible to removal

Cation	Average Concentration (mg/L)	Average Ionic Strength (mE/L)
Aluminum (as Al^{3+})	0.3	0.03
Calcium (as Ca^{2+})	49.5	2.47
Magnesium (as Mg^{2+})	1.5	0.12
Potassium (as K^{+})	10.5	0.27
Vanadium (as VO^{2+})	0.4	0.02
Total	**62.0**	**2.91**

To provide for a conservative approach, a design cation concentration of 100 mg/L and ionic strength of 5.0 mE/L are used.

7.2 Ion Exchange Unit and Resin Design Parameters

- Service Rate: 3 gpm/ft^3
- Resin Depth 30 inches
- Resin Capacity: 30 kilograins CaCO3/ft^3 or 38.6 E/ft^3
- Salt Usage 10 lbs/ft^3 as a 15% (wt) brine
- Backwash Rate: 7 gpm/ft^2 for 10 minutes
- Regeneration Rate: 0.5 gpm/ft^3
- Rinse Rate: 3 gpm/ft^3
- Rinse Volume: 4 Bed Volumes (BVs)

7.3 Ion Exchange Unit Size and Resin Volume

Required volume of ion exchange resin based on flow:

20 gpm ÷ 3 gpm/ft^3 = 6.67, say 7 ft^3

Check capacity and frequency of regeneration:

Capacity: 7 ft^3 x 38.6 E/ft^3 = 270.2 equivalents

Frequency of regeneration: 270.2 E ÷ (20 gpm x 1440 min/day x 3.785 L/gal x 0.005 E/L) = 0.5 day **TOO HIGH**

Re-compute ion exchange volume based upon a once-a-day regeneration frequency

Required capacity: 20 gpm x 1,440 min/day x 3.785 L/gal x 0.005 E/L = 545 equivalents

Ion exchange resin volume: 545 E ÷ 38.6 E/ft^3 = 14.1, say 15 ft^3

Ion exchange unit size: 15 ft^3 ÷ 2.5 ft = 6 ft^2 and $(6\ ft^2 \times 4 \div \pi)^{1/2}$ = 2.8, say 3.0 ft diameter (7 ft^2)

→ Call for two (2) 3-foot diameter ion exchange units, each holding 15 ft^3 of resin. Units to be installed in parallel with one operating and the other either regenerating or standing by.

7.4 <u>Waste Regenerantion Fluids</u>

Backwash volume: 7 gpm/ft^2 x 7 ft^2 x 10 min = 490 gallons

Regenerant volume: 10 lbs/ft^3 resin x 15 ft^3 resin ÷ 1.5 lbs/gal = 100 gallons

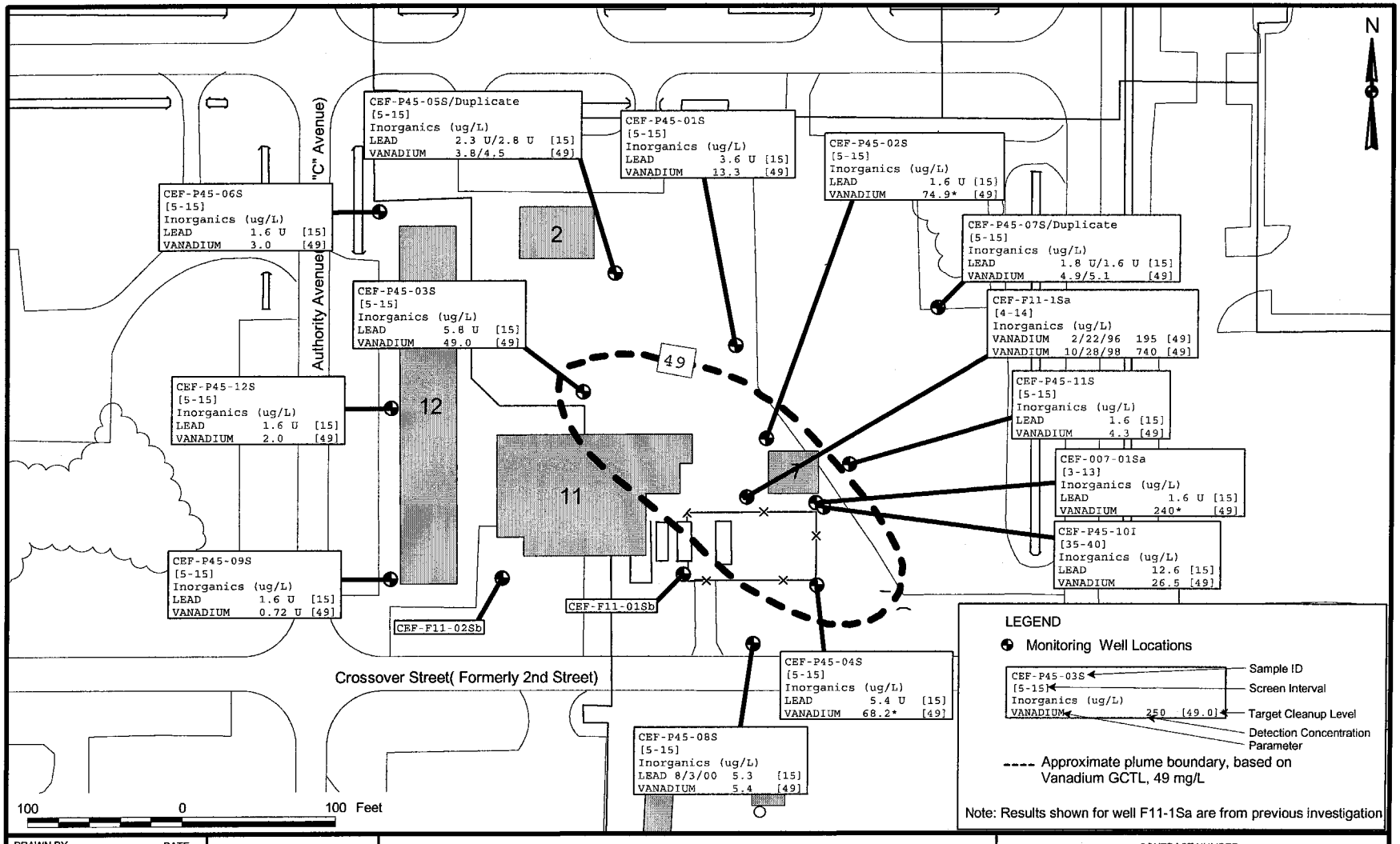
Rinse volume: 4 x 15 ft^3 x 7.486 gal/ft^3 = 449 gallons

Only need to store waste regenerant and first two BVs of rinse water for offsite treatment and disposal. Spent backwash and last two BVs of rinse water can simply be sewered.

Storage requirement: 100 + 125 = 225 gallons per day.

@ 7-day holding capacity, required storage tank volume: 225 gal/day x 7 days = 1,575 gallons

→ Call for a 6-foot diameter 8 feet high storage tank with a working capacity of 1,600 gallons. Tank to be of closed-top cylindrical vertical configuration and manufactured of fiberglass.



DRAWN BY MJJ	DATE 02Oct00	GROUNDWATER RESULTS - RI SITE 45 FEASIBILITY STUDY REPORT NAVAL AIR STATION CECIL FIELD JACKSONVILLE, FLORIDA	CONTRACT NUMBER 0039
CHECKED BY	DATE		APPROVED BY — DATE 01/11/01
COST/SCHEDULE-AREA			APPROVED BY — DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-4 — REV 0

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APPENDIX B

NATURAL ATTENUATION MODELING

B.1 ATTENUATION OF MAXIMUM SOURCE CONCENTRATION

B.2 ATTENUATION OF AVERAGE PLUME CONCENTRATION

B.1

ATTENUATION OF MAXIMUM SOURCE CONCENTRATION

ECTran Version 2.0 for Excel 4.0 & 5.0

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TETRA TECH NUS, INC.

SITE: Site 45 Job # 0039 **INVESTIGATOR:** RRM **DATE:** 01/10/2001

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
		EXPOSURE POINT: (UNDERS, FL)	UNDERS	LEACHATE CONCENTRATION (YES,NO) ?	NO
CONTAMINANT:	Vanadium	UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	1.550E+01
		WATER CRITERIA (UG/L):	4.90E+01	CONSTANT CONCENTRATION (YES,NO)?	NO
HALF-LIFE (YRS):	0.00E+00			TRY NEW GOAL:	1.03E+00
SPECIFIC ACTIVITY (Ci/g):	0.00E+00	TIME FRAME (YRS):	1500	ACCEPTABLE!	DECREASE

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	1.13E+00
Kl (L/KG):	1.86E+01	LENGTH (FT):	260
		WIDTH (FT):	105
DEPLETING SOURCE:		**IS THERE A CLAY LINER LAYER (YES,NO)?**	NO
WASTE CHARACTERISTICS:		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	1.55E+01	HOW MANY SUBLAYERS (1 - 10)?	3
INPUT FOLLOWING PARAMETERS:		TOTAL THICKNESS (UP TO 30 FT) (FT):	10
THICKNESS (FT):	5	SATURATION RATE:	0.95
SATURATION RATE:	0.6	POROSITY:	0.2
POROSITY:	0.25	BULK DENSITY (G/CM^3):	1.78
BULK DENSITY (G/CM^3)	1.5	Kd (L/KG):	1.00E-05

IS THERE A TYPE 1 LAYER (YES,NO)?	NO	**IS THERE A TYPE 2 LAYER (YES,NO)?**	NO
THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
HOW MANY SUBLAYERS (1 - 10)?	6	HOW MANY SUBLAYERS (1 - 10)?	5
TOTAL THICKNESS (UP TO 30 FT) (FT):	2.20E+01	TOTAL THICKNESS (UP TO 30 FT) (FT):	20
SATURATION RATE:	0.95	SATURATION RATE:	0.13
POROSITY:	0.2	POROSITY:	0.3
BULK DENSITY (G/CM^3)	1.5	BULK DENSITY (G/CM^3)	1.5
Kd (L/KG):	1.00E-05	Kd (L/KG):	1.00E-05
INITIAL SOIL CONC. (MG/KG):	0	INITIAL SOIL CONC. (MG/KG):	0

SATURATED LAYER

TOTAL SATURATED ZONE THICKNESS, B (FT):	30	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	2.1
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR):	21	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	1.13
Kd (L/KG):	1.86E+01	SPECIFY MIXING DEPTH (Computed from formula if input NO)	no
POROSITY:	0.25	MIXING DEPTH, H (FT):	26.8
VERTICAL DISPERSIVITY, Az (FT):	0.17	TIME OF PUMPING STOP, P&T (YEARS):	0
LONGITUDINAL DISPERSIVITY, Ax (FT):	5.0	AGE (YRS):	0
LATERAL DISPERSIVITY, Ay (FT):	0.5	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	0
INITIAL CONC. (ug/L):	740	DISTANCE TO F.L.:	50

PREDICTED IMPACTS:		TIME OF MAXIMUM (YR)
SATURATED LAYER CONCENTRATION:	7.40E+02 (UG/L)	0
FENCE LINE CONCENTRATION:	1.07E-04 (UG/L)	120

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE:	Job # 0039	**CONTAMINANT:**	**Vanadium**
		HALF-LIFE (YRS):	
		LAYER 2:	0.00E+00
INVESTIGATOR:	RRM	**SATURATED LAYER**	0.00E+00
DATE:	01/10/2001	**DOWNGRADIENT**	0.00E+00
		INITIAL CONC. (ug/L):	7.40E+02

SATURATED LAYER

INFILT (FT/YR):	1.13					B (FT):	30	Vzo (FT/YR):	2.1
LENGTH (FT):	260					GW Q3 (L/DAY):	3.54E+03		
WIDTH (FT):	105			Kd (L/KG):	1.86E+01	GW V. (FT/YR):	21.00	Kd (L/KG):	18.6
POROSITY 2:	0.3			SATURATION:	1.00	H (FT):	26.7916	RETARDATION:	112.6
POROSITY SAT. LAYER:	0.25			THICKNESS (FT):	26.79	EFF. POROSITY:	0.25	q (FT/YR) :	1.13
DENSITY 2 (G/CM3):	1.5			DECAY (1/DAY):	0.00E+00	DISPERSIVITY:		DECAY (1/YR):	1.5E-01
DENSITY GMA (G/CM3):	1.50			CBo (PPB):	7.40E+02	Az (FT):	0.17		
				CU2 (PPB):	0.00E+00	Ax (FT):	5.00	P&T (YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	2.39E+03	Q2 (L/DAY):	1.15E+03	Ay (FT):	0.50	DISTANCE TO F.L. (FT):	50

TIME INTERVAL (YRS)	30	SOURCE AREA CONC.(GMA)	FENCE LINE CONC.
ELAPSED TIME - YRS	LAYER 2(PPB)	(UG/L)	(UG/L)
0	8.33E+02	7.40E+02	0.00E+00
30	6.54E+02	7.21E+02	1.87E-08
60	5.14E+02	6.97E+02	4.06E-05
90	4.03E+02	6.70E+02	1.03E-04
120	3.17E+02	6.40E+02	1.07E-04
150	2.49E+02	6.10E+02	1.03E-04
180	1.95E+02	5.79E+02	9.93E-05
210	1.53E+02	5.49E+02	9.49E-05
240	1.20E+02	5.18E+02	9.03E-05
270	9.45E+01	4.89E+02	8.57E-05
300	7.42E+01	4.61E+02	8.11E-05
330	5.83E+01	4.34E+02	7.66E-05
360	4.58E+01	4.08E+02	7.23E-05
390	3.59E+01	3.83E+02	6.81E-05
420	2.82E+01	3.60E+02	6.41E-05
450	2.21E+01	3.38E+02	6.02E-05
480	1.74E+01	3.17E+02	5.66E-05
510	1.37E+01	2.97E+02	5.31E-05
540	1.07E+01	2.78E+02	4.98E-05
570	8.42E+00	2.61E+02	4.67E-05
600	6.61E+00	2.44E+02	4.38E-05
630	5.19E+00	2.29E+02	4.10E-05
660	4.07E+00	2.14E+02	3.85E-05
690	3.20E+00	2.01E+02	3.60E-05
720	2.51E+00	1.88E+02	3.37E-05
750	1.97E+00	1.76E+02	3.16E-05
780	1.55E+00	1.65E+02	2.96E-05
810	1.22E+00	1.54E+02	2.77E-05
840	9.55E-01	1.44E+02	2.59E-05
870	7.50E-01	1.35E+02	2.43E-05
900	5.89E-01	1.26E+02	2.27E-05
930	4.62E-01	1.18E+02	2.13E-05
960	3.63E-01	1.11E+02	1.99E-05
990	2.85E-01	1.03E+02	1.86E-05
1020	2.24E-01	9.68E+01	1.74E-05
1050	1.76E-01	9.06E+01	1.63E-05
1080	1.38E-01	8.48E+01	1.53E-05
1110	1.08E-01	7.93E+01	1.43E-05
1140	8.50E-02	7.42E+01	1.34E-05
1170	6.68E-02	6.94E+01	1.25E-05
1200	5.24E-02	6.50E+01	1.17E-05
1230	4.12E-02	6.08E+01	1.09E-05
1260	3.23E-02	5.69E+01	1.02E-05
1290	2.54E-02	5.32E+01	9.58E-06
1320	1.99E-02	4.98E+01	8.96E-06
1350	1.56E-02	4.66E+01	8.39E-06
1380	1.23E-02	4.36E+01	7.85E-06
1410	9.64E-03	4.08E+01	7.34E-06
1440	7.57E-03	3.82E+01	6.87E-06
1470	5.95E-03	3.57E+01	6.43E-06
1500	4.67E-03	3.34E+01	6.02E-06
MAXIMUM:	8.33E+02	7.40E+02	1.07E-04

B.2

ATTENUATION OF AVERAGE PLUME CONCENTRATION

ECTran Version 2.0 for Excel 4.0 & 5.0

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TETRA TECH NUS, INC.

SITE: Site 45 Job # 0039 **INVESTIGATOR:** RRM **DATE:** 01/10/2001

CHEMICAL CHARACTERISTICS		ITERATIVE DECISION-MAKING BOX			
CONTAMINANT:	Vanadium	EXPOSURE POINT: (UNDERS, FL)	UNDERS	LEACHATE CONCENTRATION (YES,NO) ?	NO
		UNDERS: Under source, FL: Fenceline		INPUT SOLID-PHASE CONCENTRATION (MG/KG)	2.760E+02
		WATER CRITERIA (UG/L):	4.90E+01	CONSTANT CONCENTRATION (YES,NO)?	NO
HALF-LIFE (YRS):	0.00E+00			TRY NEW GOAL:	6.41E+01
SPECIFIC ACTIVITY (Ci/g):	0.00E+00	TIME FRAME (YRS):	1500	ACCEPTABLE!	DECREASE

SOURCE-TERM INFORMATION		ENGINEERING CONTROL INFORMATION	
Ke:	1.00	INFILT(FT/YR):	1.13E+00
Kl (L/KG):	1.86E+01	LENGTH (FT):	260
		WIDTH (FT):	105
DEPLETING SOURCE:		**IS THERE A CLAY LINER LAYER (YES,NO)?**	NO
WASTE CHARACTERISTICS:		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
INITIAL SOLID-PHASE CONCENTRATION (MG/KG):	1.55E+01	HOW MANY SUBLAYERS (1 - 10)?	3
INPUT FOLLOWING PARAMETERS:		TOTAL THICKNESS (UP TO 30 FT) (FT):	10
THICKNESS (FT):	5	SATURATION RATE:	0.95
SATURATION RATE:	0.6	POROSITY:	0.2
POROSITY:	0.25	BULK DENSITY (G/CM^3):	1.78
BULK DENSITY (G/CM^3)	1.5	Kd (L/KG):	1.00E-05

IS THERE A TYPE 1 LAYER (YES,NO)?	NO	**IS THERE A TYPE 2 LAYER (YES,NO)?**	NO
THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION		THE FOLLOWING DATA ARE NOT USED IN THIS CALCULATION	
HOW MANY SUBLAYERS (1 - 10)?	6	HOW MANY SUBLAYERS (1 - 10)?	5
TOTAL THICKNESS (UP TO 30 FT) (FT):	2.20E+01	TOTAL THICKNESS (UP TO 30 FT) (FT):	20
SATURATION RATE:	0.95	SATURATION RATE:	0.13
POROSITY:	0.25	POROSITY:	0.3
BULK DENSITY (G/CM^3)	1.5	BULK DENSITY (G/CM^3)	1.5
Kd (L/KG):	1.00E-05	Kd (L/KG):	1.00E-05
INITIAL SOIL CONC. (MG/KG):	0	INITIAL SOIL CONC. (MG/KG):	0

SATURATED LAYER

TOTAL SATURATED ZONE THICKNESS, B (FT):	30	VERTICAL SEEPAGE VELOCITY, Vzo (FT/YR):	2.1
HORIZONTAL SEEPAGE VELOCITY, V (FT/YR):	21	DOWNGRADIENT AREA INFILTRATION RATE, q (FT/YR)	1.13
Kd (L/KG):	1.86E+01	SPECIFY MIXING DEPTH (Computed from formula if input NO)	no
POROSITY:	0.25	MIXING DEPTH, H (FT):	26.8
VERTICAL DISPERSIVITY, Az (FT):	0.17	TIME OF PUMPING STOP, P&T (YEARS):	0
LONGITUDINAL DISPERSIVITY, Ax (FT):	5.0	AGE (YRS):	0
LATERAL DISPERSIVITY, Ay (FT):	0.5	CONC. IN UPGRADIENT GROUNDWATER,CU2 (UG/L)	0
INITIAL CONC. (ug/L):	180	DISTANCE TO F.L.:	50

PREDICTED IMPACTS:		TIME OF MAXIMUM (YR)
SATURATED LAYER CONCENTRATION:	2.11E+02 (UG/L)	120
FENCE LINE CONCENTRATION:	3.17E-05 (UG/L)	180

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

SITE:	Job # 0039	**CONTAMINANT:**	**Vanadium**		
		HALF-LIFE (YRS):			
		LAYER 2:	0.00E+00		
INVESTIGATOR:	RRM	**SATURATED LAYER**	0.00E+00		
DATE:	01/10/2001	**DOWNGRADIENT**	0.00E+00	INITIAL CONC. (ug/L):	1.80E+02

SATURATED LAYER

INFILT (FT/YR):	1.13					B (FT):	30	Vzo (FT/YR):	2.1
LENGTH (FT):	260					GW Q3 (L/DAY):	3.54E+03		
WIDTH (FT):	105			Kd (L/KG):	1.86E+01	GW V. (FT/YR):	21.00	Kd (L/KG):	18.6
POROSITY 2:	0.3			SATURATION:	1.00	H (FT):	26.7916	RETARDATION:	112.6
POROSITY SAT. LAYER:	0.25			THICKNESS (FT):	26.79	EFF. POROSITY:	0.25	q (FT/YR) :	1.13
DENSITY 2 (G/CM3):	1.5			DECAY (1/DAY):	0.00E+00	DISPERSIVITY:		DECAY (1/YR):	1.5E-01
DENSITY GMA (G/CM3):	1.50			CBo (PPB):	1.80E+02	Az (FT):	0.17		
				CU2 (PPB):	0.00E+00	Ax (FT):	5.00	P&T (YEARS):	0
AGE (YEARS):	0	Q1 (L/DAY):	2.39E+03	Q2 (L/DAY):	1.15E+03	Ay (FT):	0.50	DISTANCE TO F.L. (FT):	50

TIME INTERVAL (YRS)	30	SOURCE AREA CONC.(GMA)	FENCE LINE CONC.
ELAPSED TIME - YRS	LAYER 2(PPB)	(UG/L)	(UG/L)
0	8.33E+02	1.80E+02	0.00E+00
30	6.54E+02	1.97E+02	4.54E-09
60	5.14E+02	2.07E+02	9.88E-06
90	4.03E+02	2.11E+02	2.62E-05
120	3.17E+02	2.11E+02	2.99E-05
150	2.49E+02	2.08E+02	3.12E-05
180	1.95E+02	2.03E+02	3.17E-05
210	1.53E+02	1.97E+02	3.16E-05
240	1.20E+02	1.90E+02	3.11E-05
270	9.45E+01	1.81E+02	3.03E-05
300	7.42E+01	1.73E+02	2.93E-05
330	5.83E+01	1.64E+02	2.81E-05
360	4.58E+01	1.56E+02	2.69E-05
390	3.59E+01	1.47E+02	2.56E-05
420	2.82E+01	1.39E+02	2.43E-05
450	2.21E+01	1.31E+02	2.30E-05
480	1.74E+01	1.23E+02	2.18E-05
510	1.37E+01	1.16E+02	2.06E-05
540	1.07E+01	1.09E+02	1.94E-05
570	8.42E+00	1.02E+02	1.82E-05
600	6.61E+00	9.61E+01	1.71E-05
630	5.19E+00	9.02E+01	1.61E-05
660	4.07E+00	8.45E+01	1.51E-05
690	3.20E+00	7.92E+01	1.42E-05
720	2.51E+00	7.43E+01	1.33E-05
750	1.97E+00	6.96E+01	1.25E-05
780	1.55E+00	6.52E+01	1.17E-05
810	1.22E+00	6.10E+01	1.10E-05
840	9.55E-01	5.71E+01	1.03E-05
870	7.50E-01	5.35E+01	9.61E-06
900	5.89E-01	5.01E+01	9.00E-06
930	4.62E-01	4.69E+01	8.43E-06
960	3.63E-01	4.39E+01	7.89E-06
990	2.85E-01	4.11E+01	7.39E-06
1020	2.24E-01	3.84E+01	6.91E-06
1050	1.76E-01	3.60E+01	6.47E-06
1080	1.38E-01	3.37E+01	6.06E-06
1110	1.08E-01	3.15E+01	5.67E-06
1140	8.50E-02	2.95E+01	5.30E-06
1170	6.68E-02	2.76E+01	4.96E-06
1200	5.24E-02	2.58E+01	4.64E-06
1230	4.12E-02	2.41E+01	4.35E-06
1260	3.23E-02	2.26E+01	4.07E-06
1290	2.54E-02	2.11E+01	3.81E-06
1320	1.99E-02	1.98E+01	3.56E-06
1350	1.56E-02	1.85E+01	3.33E-06
1380	1.23E-02	1.73E+01	3.12E-06
1410	9.64E-03	1.62E+01	2.92E-06
1440	7.57E-03	1.52E+01	2.73E-06
1470	5.95E-03	1.42E+01	2.55E-06
1500	4.67E-03	1.33E+01	2.39E-06
MAXIMUM:	8.33E+02	2.11E+02	3.17E-05

APPENDIX C

DETAILED COST ESTIMATES

C.1 SOIL ALTERNATIVE 2
C.2 SOIL ALTERNATIVE 3
C.3 GROUNDWATER ALTERNATIVE 2
C.4 GROUNDWATER ALTERNATIVE 3

C.1

SOIL ALTERNATIVE 2

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
SOIL REMEDIAL ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 PROJECT PLANNING												
1.1 Prepare Remedial Action Plan	100	hr			$35.00		$0	$0	$3,500	$0	$3,500	
2 MOBILIZATION/DEMOBILIZATION												
2.1 Mobilize/Demobilize Drill Rig	1	ls	$2,495.00				$2,495	$0	$0	$0	$2,495	
3 DECONTAMINATION												
3.1 Decontamination of Drill Rig	1	ls	$500.00				$500	$0	$0	$0	$500	
4 MONITORING WELL INSTALLATION												
4.1 Install Monitoring Well	15	lf	$24.00				$360	$0	$0	$0	$360	
4.2 Well Development	2	hr	$35.00				$70	$0	$0	$0	$70	
4.3 Collect/Conatinerize IDW	1	ea	$50.00				$50	$0	$0	$0	$50	
4.4 Transport/Dispose IDW Off Site	1	drum	$150.00				$150	$0	$0	$0	$150	
5 INSTITUTIONAL CONTROLS												
5.1 Prepare Deed Restrictions & LUCIPs	100	hr			$35.00		$0	$0	$3,500	$0	$3,500	
Subtotal							$3,625	$0	$7,000	$0	$10,625	
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%		
							$3,625	$0	$6,160	$0	$9,785	
Overhead on Labor Cost @ 30%									$1,848		$1,848	
G & A on Labor Cost @ 10%									$616		$616	
G & A on Material Cost @ 10%								$0			$0	
G & A on Subcontract Cost @ 10%							$363				$363	
Total Direct Cost							$3,988	$0	$8,624	$0	$12,612	
Indirects on Total Direct Cost @ 35%											$4,414	
Profit on Total Direct Cost @ 10%											$1,261	
Subtotal											$18,287	
Health & Safety Monitoring @ 5%											$914	
Total Field Cost											$19,201	
Contingency on Total Field Costs @ 20%											$3,840	
Engineering on Total Field Cost @ 10%											$1,920	
TOTAL COST											**$24,961**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
SOIL REMEDIAL ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING
Annual Cost

Item	Item Cost Year 1 (1)	Item Cost Years 2 & 3 (2)	Item Cost Year 4 - 30 (3)	Item Cost Every 5 Years	Notes
Groundwater Sampling	$17,440	$8,720	$4,360		Labor, Field Supplies
Analysis/Water	$960	$480	$240		Analyze samples from 11 wells plus one QA sample for vanadium. Quarterly year 1; semi-annually for years 2 - 3 and annually for years 4 - 30.
Soil Sampling	$1,090	$1,090	$1,090		Labor, Field Supplies
Analysis/Soil	$2,065	$2,065	$2,065		Analyze 6 surface (0-2 ft) soil samples and one QA sample for PAHs, TRPHs, and arsenic. Annually for 30 years.
Report	$4,000	$2,000	$1,000		Document sampling events and results
Site Inspection	$1,000	$1,000	$1,000		One day annual inspection to verify continued implementation of institutional controls
Site Review				$7,000	
TOTALS	$26,555	$15,355	$9,755	$7,000	

(1) Groundwater sampling would occur quarterly for the first year. Soil sampling annually.
(2) Groundwater sampling would occur semi-annually for the years 2 - 3. Soil sampling annually.
(3) Groundwater sampling would occur annually for years 4 - 30. Soil sampling annually.

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
SOIL REMEDIAL ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$24,961		$24,961	1.000	$24,961
1		$26,555	$26,555	0.935	$24,829
2		$15,355	$15,355	0.873	$13,405
3		$15,355	$15,355	0.816	$12,530
4		$9,755	$9,755	0.763	$7,443
5		$16,755	$16,755	0.713	$11,946
6		$9,755	$9,755	0.666	$6,497
7		$9,755	$9,755	0.623	$6,077
8		$9,755	$9,755	0.582	$5,677
9		$9,755	$9,755	0.544	$5,307
10		$16,755	$16,755	0.508	$8,512
11		$9,755	$9,755	0.475	$4,634
12		$9,755	$9,755	0.444	$4,331
13		$9,755	$9,755	0.415	$4,048
14		$9,755	$9,755	0.388	$3,785
15		$16,755	$16,755	0.362	$6,065
16		$9,755	$9,755	0.339	$3,307
17		$9,755	$9,755	0.317	$3,092
18		$9,755	$9,755	0.296	$2,887
19		$9,755	$9,755	0.277	$2,702
20		$16,755	$16,755	0.258	$4,323
21		$9,755	$9,755	0.242	$2,361
22		$9,755	$9,755	0.226	$2,205
23		$9,755	$9,755	0.211	$2,058
24		$9,755	$9,755	0.197	$1,922
25		$16,755	$16,755	0.184	$3,083
26		$9,755	$9,755	0.172	$1,678
27		$9,755	$9,755	0.161	$1,571
28		$9,755	$9,755	0.150	$1,463
29		$9,755	$9,755	0.141	$1,375
30		$16,755	$16,755	0.131	$2,195
				TOTAL PRESENT WORTH	$186,270

C.2

SOIL ALTERNATIVE 3

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
SOIL REMEDIAL ALTERNATIVE 3: EXCAVATION AND OFF-BASE TREATMENT & DISPOSAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Remedial Action Plan	200	hours			$35.00		$0	$0	$7,000	$0	$7,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer	2	mo	$200.50				$401	$0	$0	$0	$401
2.2 Storage Trailer (1)	2	mo	$103.00				$206	$0	$0	$0	$206
2.3 Construction Survey	1	ls	$1,575.00				$1,575	$0	$0	$0	$1,575
2.4 Equipment Mobilization/Demobilization	4	ea			$48.00	$198.00	$0	$0	$192	$792	$984
2.5 Site Utilities	2	mo	$500.00				$1,000	$0	$0	$0	$1,000
2.6 Mobilization/Demobilization of Asphalt Crushing	1	ls	$1,600.00				$1,600	$0	$0	$0	$1,600
3 DECONTAMINATION											
3.1 Equipment Decon Pad	1	ls		$5,800.00	$6,650.00	$700.00	$0	$5,800	$6,650	$700	$13,150
3.2 Decontamination Trailer	2	mo	$2,200.00				$4,400	$0	$0	$0	$4,400
3.3 Decon Water	2,000	gal	$0.20				$400	$0	$0	$0	$400
3.4 Decon Water Storage Tank, 6,000 gallon	2	mo	$600.00				$1,200	$0	$0	$0	$1,200
3.5 Clean Water Storage Tank, 4,000 gallon	2	mo	$540.00				$1,080	$0	$0	$0	$1,080
3.6 Disposal of Decon Waste (liquid & solid)	2	mo	$900.00				$1,800	$0	$0	$0	$1,800
3.7 PPE (5 p * 5 days * 8 weeks)	200	day		$30.90			$0	$6,180	$0	$0	$6,180
4 EXCAVATE CONTAMINATED SOIL											
4.1 Clear and grub, cut & chip light, trees to 6" diam,	1.8	ac			$1,175.00	$1,050.00	$0	$0	$2,115	$1,890	$4,005
4.2 Pulverize asphalt to less than 3" particle size	4,840	sy	$2.16				$10,454	$0	$0	$0	$10,454
4.3 Excavate Soil/Pavement	7,800	cy			$0.60	$0.55	$0	$0	$4,680	$4,290	$8,970
4.4 Front End Loader, 150 ft haul	7,800	cy			$0.81	$0.96	$0	$0	$6,318	$7,488	$13,806
4.5 Shoring around Building Foundations, 1000 ft	5	mbf		$740.00	$510.00	$72.00	$0	$3,700	$2,550	$360	$6,610
4.6 Post-excavation Soil Analysis: PAH, TRPH, Arsenic	80	ea	$590.00	$5.00	$30.00		$47,200	$400	$2,400	$0	$50,000
5 TREATMENT & DISPOSAL											
5.1 Low Temperature Thermal Desorption (LTTD)	3,900	cy	$75.00				$292,500	$0	$0	$0	$292,500
5.2 Chemical Fixation	7,825	cy	$50.00				$391,250	$0	$0	$0	$391,250
5.3 Waste Characterization Testing (TCLP),1 per 1000 cy	8	ea	$785.00	$5.00	$30.00		$6,280	$40	$240	$0	$6,560
5.4 Off-Site Disposal	8,600	cy	$100.00				$860,000	$0	$0	$0	$860,000
6 SITE RESTORATION											
6.1 Import clean backfill	5,410	cy		$8.55			$0	$46,256	$0	$0	$46,256
6.2 Place, grade, and compact (4 passes, 1' lifts) backfill	5,410	cy			$0.28	$0.47	$0	$0	$1,515	$2,543	$4,058
6.3 Furnish and place topsoil - 6" layer	8,712	sy		$2.46	$0.41	$0.35	$0	$21,432	$3,572	$3,049	$28,053
6.4 Fine Grading and seeding, incl. lime, fert, and seed	8,712	sy		$0.26	$1.16	$0.18	$0	$2,265	$10,106	$1,568	$13,939
6.5 Prepare and roll sub-base, large areas	4,840	sy			$0.25	$0.38	$0	$0	$1,210	$1,839	$3,049
6.6 Asphalt Parking Lot, 6" stone base, 2" binder, 1" topping	43,560	sf		$1.13	$0.14	$0.17	$0	$49,223	$6,098	$7,405	$62,726
7 MISCELLANEOUS											
7.1 Construction Oversite (5p*5days*8 weeks)	200	days			$320.00		$0	$0	$64,000	$0	$64,000
7.2 Post Construction Documents	100	hr			$40.00		$0	$0	$4,000	$0	$4,000
Subtotal							1621346.4	135294.94	122646.04	31924.46	$1,911,212
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$1,621,346	$163,030	$107,929	$28,094	$1,920,399
Overhead on Labor Cost @ 30%									$32,379		$32,379
G & A on Labor Cost @ 10%									$10,793		$10,793
G & A on Material Cost @ 10%								$16,303			$16,303
G & A on Subcontract Cost @ 10%							$162,135				$162,135
Total Direct Cost							$1,783,481	$179,333	$151,100	$28,094	$2,142,008
Indirects on Total Direct Cost @ 35%											$749,703
Profit on Total Direct Cost @ 10%											$214,201

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
SOIL REMEDIAL ALTERNATIVE 3: EXCAVATION AND OFF-BASE TREATMENT & DISPOSAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Subtotal											$3,105,911
Health & Safety Monitoring @ 1%											$31,059
Total Field Cost											$3,136,971
Contingency on Total Field and Subcontractor Costs @ 20%											$627,394
Engineering on Total Field Cost @ 10%			(Total Field Cost minus Subcontractor's Total Direct Cost)								$135,349
TOTAL COST											**$3,899,714**

C.3

GROUNDWATER ALTERNATIVE 2

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 2: NATURAL ATTENUATION, INSTITUTIONAL CONTROLS, AND MONITORING

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Remedial Action Plan	100	hr			$35.00		$0	$0	$3,500	$0	$3,500
2 MOBILIZATION/DEMOBILIZATION											
2.1 Mobilize/Demobilize Drill Rig	1	ls	$2,495.00				$2,495	$0	$0	$0	$2,495
3 DECONTAMINATION											
3.1 Decontamination of Drill Rig	1	ls	$500.00				$500	$0	$0	$0	$500
4 MONITORING WELL INSTALLATION											
4.1 Install Monitoring Well	15	lf	$24.00				$360	$0	$0	$0	$360
4.2 Well Development	2	hr	$35.00				$70	$0	$0	$0	$70
4.3 Collect/Conatinerize IDW	1	ea	$50.00				$50	$0	$0	$0	$50
4.4 Transport/Dispose IDW Off Site	1	drum	$150.00				$150	$0	$0	$0	$150
5 INSTITUTIONAL CONTROLS											
5.1 Prepare Deed Restrictions & LUCIPs	100	hr			$35.00		$0	$0	$3,500	$0	$3,500
Subtotal							$3,625	$0	$7,000	$0	$10,625
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$3,625	$0	$6,160	$0	$9,785
Overhead on Labor Cost @ 30%									$1,848		$1,848
G & A on Labor Cost @ 10%									$616		$616
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$363				$363
Total Direct Cost							$3,988	$0	$8,624	$0	$12,612
Indirects on Total Direct Cost @ 35%											$4,414
Profit on Total Direct Cost @ 10%											$1,261
Subtotal											$18,287
Health & Safety Monitoring @ 5%											$914
Total Field Cost											$19,201
Contingency on Total Field Costs @ 20%											$3,840
Engineering on Total Field Cost @ 10%											$1,920
TOTAL COST											**$24,961**

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 2: NATURAL ATTENUATION, INSTITUTIONAL CONTROLS, AND MONITORING
Annual Cost

Item	Item Cost Year 1 (1)	Item Cost Years 2 & 3 (2)	Item Cost Year 4 - 30 (3)	Item Cost Every 5 Years	Notes
Sampling	$17,440	$8,720	$4,360		Labor, Field Supplies
Analysis/Water	$960	$480	$240		Analyze samples from 11 wells plus one QA sample for vanadium. Quarterly year 1; semi-annually for years 2 - 3 and annually for years 4 - 30.
Report	$4,000	$2,000	$1,000		Document sampling events and results
Site Inspection	$1,000	$1,000	$1,000		One day annual inspection to verify continued implementation of institutional controls
Site Review				$7,000	
TOTALS	$23,400	$12,200	$6,600	$7,000	

(1) Sampling would occur quarterly for the first year.
(2) Sampling would occur semi-annually for the years 2 - 3.
(3) Sampling would occur annually for years 4 - 30.

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 2: NATURAL ATTENUATION, INSTITUTIONAL CONTROLS, AND MONITORING
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$24,961		$24,961	1.000	$24,961
1		$23,400	$23,400	0.935	$21,879
2		$12,200	$12,200	0.873	$10,651
3		$12,200	$12,200	0.816	$9,955
4		$6,600	$6,600	0.763	$5,036
5		$13,600	$13,600	0.713	$9,697
6		$6,600	$6,600	0.666	$4,396
7		$6,600	$6,600	0.623	$4,112
8		$6,600	$6,600	0.582	$3,841
9		$6,600	$6,600	0.544	$3,590
10		$13,600	$13,600	0.508	$6,909
11		$6,600	$6,600	0.475	$3,135
12		$6,600	$6,600	0.444	$2,930
13		$6,600	$6,600	0.415	$2,739
14		$6,600	$6,600	0.388	$2,561
15		$13,600	$13,600	0.362	$4,923
16		$6,600	$6,600	0.339	$2,237
17		$6,600	$6,600	0.317	$2,092
18		$6,600	$6,600	0.296	$1,954
19		$6,600	$6,600	0.277	$1,828
20		$13,600	$13,600	0.258	$3,509
21		$6,600	$6,600	0.242	$1,597
22		$6,600	$6,600	0.226	$1,492
23		$6,600	$6,600	0.211	$1,393
24		$6,600	$6,600	0.197	$1,300
25		$13,600	$13,600	0.184	$2,502
26		$6,600	$6,600	0.172	$1,135
27		$6,600	$6,600	0.161	$1,063
28		$6,600	$6,600	0.150	$990
29		$6,600	$6,600	0.141	$931
30		$13,600	$13,600	0.131	$1,782
				TOTAL PRESENT WORTH	$147,119

C.4

GROUNDWATER ALTERNATIVE 3

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 3: EXTRACTION, ON-SITE TREATMENT, SURFACE DISCHARGE, INSTITUTIONAL CONTROLS, AND MONITORING

			Unit Cost				Extended Cost				
	Quantity	Unit	Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Remedial Action Plan	300	hr			$35.00		$0	$0	$10,500	$0	$10,500
2 MOBILIZATION/DEMOBILIZATION											
2.1 Mobilize/Demobilize Drill Rig	1	ls	$2,495.00				$2,495	$0	$0	$0	$2,495
2.2 Site Utilities	1	mo	$1,000.00				$1,000	$0	$0	$0	$1,000
3 DECONTAMINATION											
3.1 Decontamination Trailer	1	mo	$2,200.00				$2,200	$0	$0	$0	$2,200
3.2 Temporary Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105
3.3 Decon Water	1000	gal		$0.20			$0	$200	$0	$0	$200
3.4 Decon Water Storage Tank, 6,000 gallon	1	mo	$600.00				$600	$0	$0	$0	$600
3.5 Clean Water Storage Tank, 4,000 gallon	1	mo	$540.00				$540	$0	$0	$0	$540
3.6 PPE (3 p * 5 days * 4 Weeks)	60	day		$30.90			$0	$1,854	$0	$0	$1,854
3.7 Disposal of Decon Waste (liquid & solid)	1	mo	$4,500.00				$4,500	$0	$0	$0	$4,500
4 MONITORING WELL INSTALLATION											
4.1 Install Monitoring Well	15	lf	$24.00				$360	$0	$0	$0	$360
4.2 Well Development	2	hr	$35.00				$70	$0	$0	$0	$70
4.3 Collect/Conatinerize IDW	1	ea	$50.00				$50	$0	$0	$0	$50
4.4 Transport/Dispose IDW Off Site	1	drum	$150.00				$150	$0	$0	$0	$150
5 GROUNDWATER EXTRACTION SYSTEM											
5.1 Extraction Wells, 6" dia	140	lf	$43.00				$6,020	$0	$0	$0	$6,020
5.2 Well Development	8	hr	$35.00				$280	$0	$0	$0	$280
5.3 Collect/Containerize IDW	8	ea	$50.00				$400	$0	$0	$0	$400
5.4 Transport/Dispose IDW Off Site	8	drums	$150.00				$1,200	$0	$0	$0	$1,200
5.5 Survey Well Location	1	ls	$1,000.00				$1,000	$0	$0	$0	$1,000
5.6 Submersible Pumps and Controls, 5 gpm, 0.5 HP	4	ea		$355.00	$154.00		$0	$1,420	$616	$0	$2,036
5.7 Collection Piping, 1 1/2" PVC, double-walled, buried	400	lf		$8.99	$12.83	$1.00	$0	$3,596	$5,132	$400	$9,128
5.8 Vault Boxes and Misc Piping/Valves at Well Head	4	ea		$399.50	$299.63		$0	$1,598	$1,199	$0	$2,797
5.9 Leak Detection Monitor	400	lf		$9.50	$4.75		$0	$3,800	$1,900	$0	$5,700
5.10 Leak Detection Loop	4	ea		$580.00	$1,109.00		$0	$2,320	$4,436	$0	$6,756
6 GROUNDWATER TREATMENT SYSTEM											
6.1 Concrete Foundation (6")	500	sf		$2.64	$4.37	$7.01	$0	$1,320	$2,185	$3,505	$7,010
6.2 Treatment System Building	500	sf		$4.08	$0.99	$0.72	$0	$2,040	$495	$360	$2,895
6.3 Equalization Tank Foundation	2.5	cy		$118.00	$81.00	$98.00	$0	$295	$203	$245	$743
6.4 Equalization Tank, 600 gallon	1	ea		$300.00	$60.00		$0	$300	$60	$0	$360
6.5 Equalization Tank Mixer, .5 HP	1	ea		$1,864.00	$30.00		$0	$1,864	$30	$0	$1,894
6.6 Horizontal-Centrifugal Transfer Pump, 25 gpm, 1 HP	2	ea		$1,625.00	$448.43		$0	$3,250	$897	$0	$4,147
6.7 Bag Filter, 20 gpm dual-element, 25-micron	1	ea		$5,000.00	$800.00		$0	$5,000	$800	$0	$5,800
6.8 Plumb/Electrify System	1	ls		$7,000.00	$6,366.00		$0	$7,000	$6,366	$0	$13,366
6.9 System Start-up and Testing	1	ls		$3,000.00	$2,900.00		$0	$3,000	$2,900	$0	$5,900
6.10 Water Softening Ion Exchange Unit, 700,000 grains	2	ea		$6,900.00	$620.00		$0	$13,800	$1,240	$0	$15,040
6.11 1,600 Gal Waste Regenerant Storage Tank	1	ea		$2,180.00	$120.00		$0	$2,180	$120	$0	$2,300
6.12 Instruments and Controls	1	ls		$2,200.00	$1,200.00		$0	$2,200	$1,200	$0	$3,400
7 INSTITUTIONAL CONTROLS											
7.1 Prepare Deed Restrictions & LUCIPs	100	hr			$35.00		$0	$0	$3,500	$0	$3,500
8 SITE RESTORATION											
8.1 Vegetate Disturbed Areas	1	ls		$500.00	$500.00		$0	$500	$500	$0	$1,000
Subtotal							$20,865	$58,037	$44,728	$4,665	$128,295
Local Area Adjustments							100.0%	120.5%	88.0%	88.0%	
							$20,865	$69,935	$39,361	$4,105	$134,265
Overhead on Labor Cost @ 30%									$11,808		$11,808
G & A on Labor Cost @ 10%									$3,936		$3,936
G & A on Material Cost @ 10%								$6,993			$6,993
G & A on Subcontract Cost @ 10%							$2,087				$2,087

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 3: EXTRACTION, ON-SITE TREATMENT, SURFACE DISCHARGE, INSTITUTIONAL CONTROLS, AND MONITORING

	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Total Direct Cost							$22,952	$76,928	$55,105	$4,105	$159,089
Indirects on Total Direct Cost @ 35%											$55,681
Profit on Total Direct Cost @ 10%											$15,909
Subtotal											$230,680
Health & Safety Monitoring @ 1%											$2,307
Total Field Cost											$232,987
Contingency on Total Field and Subcontractor Costs @ 20%											$46,597
Engineering on Total Field Cost @ 10%											$23,299
TOTAL COST											**$302,883**

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 3: EXTRACTION, ON-SITE TREATMENT, SURFACE DISCHARGE, INSTITUTIONAL CONTROLS, AND MONITORING
Operation and Maintenance Costs per Year

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
1	Energy - Electric	22,865	kWh	$0.06	$1,372	
2	Maintenance	1	ls	$2,647.47	$2,647	5% of Installation Cost
3	Regenerate Ion Exchange Unit with Sodium Chloride	54,750	lb	$0.10	$5,475	150 lb/day
4	Regenerate Ion Exchange Unit Daily Labor	260	hr	$35.00	$9,100	1.0 hr. labor/day
5	Change bag filter weekly	1	ls	$6,110.00	$6,110	0.5 hr labor plus one bag ($100) per week
6	Disposal of Waste Brine	84	kgal	$1.58	$133	1600 gal/week
7	Vanadium Testing, Influent and Effluent	104	ea	$20.00	$2,080	weekly, wastewater disposal costs
8	Quarterly Reports	4	ea	$500.00	$2,000	
	Total Cost for One Year Operation				$28,917	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 3: EXTRACTION, ON-SITE TREATMENT, SURFACE DISCHARGE, INSTITUTIONAL CONTROLS, AND MONITORING
Annual Cost

Item	Item Cost Year 1 (1)	Item Cost Years 2 & 3 (2)	Item Cost Years 4 - 18 (3)	Item Cost Every 5 years	Notes
Sampling	$17,440	$8,720	$4,360		Labor, Field Supplies
Analysis/Water	$960	$480	$240		Analyze samples from 11 wells and one QA sample for vanadium. Quarterly year 1; semi-annually years 2 - 3 and annually for years 4 - 18.
Report	$4,000	$2,000	$1,000		Document sampling events and results
Site Inspection	$1,000	$1,000	$1,000		One day annual inspection to verify continued implementation of institutional controls.
Site Review				$7,000	
TOTALS	$23,400	$12,200	$6,600	$7,000	

(1) Sampling would occur quarterly for the first year.
(2) Sampling would occur semi-annually for the years 2 - 3.
(3) Sampling would occur annually for years 4 - 18.

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
SITE 45
GROUNDWATER ALTERNATIVE 3: EXTRACTION, ON-SITE TREATMENT, SURFACE DISCHARGE, INSTITUTIONAL CONTROLS, AND MONITORING
Present Worth Analysis

Year	Capital Cost	Operation and Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$302,883			$302,883	1.000	$302,883
1		$28,917	$23,400	$52,317	0.935	$48,916
2		$28,917	$12,200	$41,117	0.873	$35,895
3		$28,917	$12,200	$41,117	0.816	$33,552
4		$28,917	$6,600	$35,517	0.763	$27,100
5		$28,917	$13,600	$42,517	0.713	$30,315
6		$28,917	$6,600	$35,517	0.666	$23,654
7		$28,917	$6,600	$35,517	0.623	$22,127
8		$28,917	$6,600	$35,517	0.582	$20,671
9		$28,917	$6,600	$35,517	0.544	$19,321
10		$28,917	$13,600	$42,517	0.508	$21,599
11		$28,917	$6,600	$35,517	0.475	$16,871
12		$28,917	$6,600	$35,517	0.444	$15,770
13		$28,917	$6,600	$35,517	0.415	$14,740
14		$28,917	$6,600	$35,517	0.388	$13,781
15		$28,917	$13,600	$42,517	0.362	$15,391
16		$28,917	$6,600	$35,517	0.339	$12,040
17		$28,917	$6,600	$35,517	0.317	$11,259
18		$28,917	$6,600	$35,517	0.296	$10,513
					TOTAL PRESENT WORTH	$696,396

APPENDIX D

VANADIUM TREATABILITY TECHNICAL MEMORANDUM

SUMMARY OF TREATABILITY TESTING OPTIONS TO EVALUATE TECHNOLOGIES FOR THE IN-SITU TREATMENT OF VANADIUM IN GROUNDWATER SITE 45 – STEAM GENERATING PLANT NAS CECIL FIELD, JACKSONVILLE, FLORIDA

1.0 INTRODUCTION

Tetra Tech NUS Corporation (TtNUS) is currently preparing a Feasibility Study (FS) for Site 45 – Steam Generating Plant at Naval Air Station (NAS) Cecil Field in Jacksonville, Florida. This FS is being prepared for Southern Division Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM) under the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0078.

The main focus of this FS is the evaluation of groundwater containing relatively low concentrations (maximum 240 μg/L) of vanadium that are, however, in excess of the Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level (GCTL) of 49 μg/L

This brief technical memorandum was prepared as a result of a decision reached by the Base Realignment Cleanup Team (BCT) during the May 15, 2001 meeting (Minute No. 1472). The purpose of this memrandum is to present a brief survey of the current state-of-the-art for the in-situ treatment of vanadium in groundwater and to outline an approach for the evaluation of one or more of the most promising remedial technologies through treatability testing.

The two following important assumptions were made for the preparation of this technical memorandum:

- Because of the very slow rate of vanadium migration predicted by the FS modeling and because of the small size (28,600 ft^2) of the vanadium plume, it was assumed that in-situ technologies that treat the vanadium in place would be more timely and cost-effective than extraction and ex-situ treatment (pump-and-treat) or technologies that depend on groundwater and contaminant movement, such as permeable reactive barriers (PRBs).

- Although the oxidation state of the vanadium in the Site 45 groundwater is unknown and would not be simple to determine, it was assumed that this vanadium would be present in one of its higher oxidation states, either as vanadium (IV) or vanadium (V), because it resulted from emissions of fuel combustion that is an oxidative process.

2.0 TECHNOLOGY SURVEY METHODOLOGY

Remedial technologies were surveyed through a literature review and Internet search. In particular, a number of documents were downloaded from the Groundwater Remediation Technologies Analysis Center (GWRTAC) site and the U.S. EPA REACHIT search engine.

The documents that were reviewed are referenced in section 5.0 of this memorandum.

3.0 POTENTIAL IN-SITU TREATMENT TECHNOLOGIES

The technology survey identified very few vanadium-specific treatment technologies. Work at only one United States Department of Energy (U.S. DOE) site (Rifle, Colorado, see first two references in Section 5.0) was vanadium-related. However, it was assumed that technologies proven to be effective for the treatment of other heavy metals, such as hexavalent chromium in particular, would also have the potential to be effective for the treatment of vanadium (IV or V).

Taking into consideration the above assumption as well as the two assumptions presented in Section 1.0, the technology survey showed that the most promising approach for the in-situ treatment of vanadium in groundwater at Site 45 would be to create a "reactive zone" within the contaminant plume. This "reactive zone" would result in immobilization of the vanadium, either through reduction and precipitation, or through adsorption, or through a combination of both processes.

The technology survey also identified the injection of reductive chemical reagents as the most likely type of technology to create such a "reactive zone." According to the information downloaded from the GWRTAC site, several such reagents have been successfully used, at least on a pilot-scale, including sodium or potassium dithionite (S_2O_4) solutions and colloidal suspensions [nano meter (E-09) particle size] of zero-valent iron (ZVI). According to the U.S. EPA REACHIT search engine, yet another reagent is a polythiocarbonate, marketed by ETUS under the name of TR-DETOX, and which is reportedly capable of both reducing and precipitating heavy metals, such as vanadium.

All of the above reagents have been proven to be effective on either a pilot- or full-scale for the treatment of hexavalent chromium. However, only ZVI, used in a PRB, has actually been proven effective on a pilot-scale for the treatment of vanadium (V) at the previously-mentioned U.S. DOE site (Rifle, Colorado).

Besides chemical injection, another type of technology that might be used for the creation of a reactive zone would be electrokinetics, as offered by such companies as Geokinetics International, Inc. and Electro Petroleum Inc. Electrokinetics would consist of installing a network of electrodes within the contaminant plume. These electrodes are reportedly capable of capturing such ionic contaminants as

vanadium in a much more effective manner than pump-and-treat. However, a review of some of the existing literature showed that electrokinetics is best suited to the treatment of highly-contaminated aquifers, which is not the case at Site 45. Also, once captured at the electrode sites, contaminants must still be extracted and treated as they would be in a conventional pump-and-treat system. Therefore, electrokinetics was not retained for further evaluation at Site 45.

4.0 TREATABILITY TESTING

The effectiveness of all of the above technologies should be verified through treatability testing.

Conceptually, this testing could be conducted as a multi-tiered process consisting of the four steps described below. The first three of these four steps would be performed on a bench-scale in a laboratory and the fourth would be performed on a pilot-scale in the field. In practice, however, it may not be necessary to perform all four steps and the availability of sufficient previous testing data may allow the by-passing of the first two, or even the first three steps.

The first laboratory bench-scale step would consist of a jar test type screening study in water. The objective of this first step would be to verify the ability of a particular reagent to reduce and precipitate vanadium and to establish chemical usage rates and other reaction parameters (e.g., ORP, pH, temperature, etc..) under optimal controlled conditions. Depending on knowledge derived from literature and/or prior work, this step might not always be necessary. The typical timeframe and cost for this first step of bench-scale testing would be approximately two to four weeks and $5,000 to $10,000, respectively. Management and oversight of testing activities, including procurement of a treatability contractor in accordance to Federal Acquisition Regulations (FAR) would typically add approximately 2 months and $15,000 to these timeframes and costs.

The second laboratory bench-scale step would consist of a batch study with a mixture of groundwater and natural matrices (soil). The objective of this second step would to evaluate the effect of natural matrices upon the effectiveness of the tested chemical and the reaction parameters, as established by the first step testing. The typical timeframe and cost for this second step of bench-scale testing would be approximately four to six weeks and $10,000 to $20,000, respectively. Management and oversight of testing activities would require an additional 2 months and $17,000.

The third laboratory bench-scale step would consist of a column study with site-specific natural matrices. The objective of this third step would be to get as close as possible to actual field conditions and to determine the impact of dynamic rather than batch testing upon the removal effectiveness and reaction parameters established by the first two steps of testing. The typical timeframe and cost for this third step

of bench-scale testing would be approximately six to eight weeks and $30,000 to $50,000, respectively. Management and oversight of testing activities would require an additional 2 months and $20,000.

Field pilot-scale testing would consist of injecting a reagent at one or two locations of the site to be tested and monitoring remediation through the collection and analysis of samples from monitoring wells strategically located around the injection point(s). The objective of this fourth step is to verify that a given technology would be effective under actual site-specific field conditions and to establish design parameters for a full-scale application. At Site 45, because of the relatively small size of the groundwater contaminant plume, field pilot-scale testing could in fact constitute a significant portion of the full-scale remedial action and be used to cleanup the area of highest vanadium contamination in the vicinity of monitoring wells CEF-F11-1Sa and CEF-007-01Sa. The typical timeframe and cost for pilot-scale testing would be approximately three to four months and $150,000 to $300,000, respectively. Management and oversight of testing activities would require an additional 2 months and $25,000.

The following table summarizes the time requirements and costs for each of the above treatability testing steps:

Step	Testing		Management & Oversight		Total	
	Duration (months)	Cost ($1,000)	Duration (months)	Cost ($1,000)	Duration (months)	Cost ($1,000)
1st Stage Lab Bench-Scale	0.5 – 1	5 – 10	2	15	2.5 - 3	20 – 25
2nd Stage Lab Bench-Scale	1 – 1.5	10 - 20	2	20	3 – 3.5	30 – 40
3rd Stage Lab Bench-Scale	1.5 – 2	30 - 50	2	25	3.5 - 4	55 – 75
Field Pilot-Scale	3 – 4	150 - 300	2	30	5 - 6	180 – 330
Totals	**6 – 8.5**	**195 - 380**	**8**	**90**	**13 – 16.5**	**285 - 470**

5.0 REFERENCES

The following document were downloaded and reviewed from an Internet search (Yahoo.com search engine, "vanadium removal"):

Title: Rifle, Colorado, Pilot Study Begins for Vanadium Removal
Publication: U.S. Department of Energy, Grand Junction Office, Perspective, Winter/Spring 2001

Title: Final Site Observational Work Plan for the UMTRA Project New Rifle Site
Publication: U.S. Department of Energy, Grand Junction Office, Document U0058601, December 1999

Title: In Situ Redox Manipulation, Subsurface Contaminants Focus Area
Publication: U.S. Department of Energy Innovative Technology Summary Report DOE/EM-0499, January 2000

Title: Innovative Technology Evaluation Repory, Dynaphore, Inc., Forager™ Sponge Technology

Publication: U.S. EPA Environmental Agency EPA/540/R-94/552, June 1995

The following documents were downloaded for review from the GWRTAC web site at http://www.gwrtac.org:

Title: An Overview of R&D Addressing In Situ Treatment of Heavy Metal Contaminants in Soil and Groundwater
Author: Edgar Berkey
Reference: Presentation for Workshop on Heavy Metal Contaminants in Water, Snowbird, Utah, August 2-4, 1999

Title: In Situ Chemical Treatment
Authors: Yujun Yin and Herbert Allen
Reference: Technology Evaluation Report TE-99-01, July 1999

Title: Remediation of Metals-Contaminated Soils and Groundwater
Authors: Cynthia Evanko and David Dzombak
Reference: Technology Evaluation Report TE-97-01, October 1997

Title: Electrokinetics
Author: Liesbet Van Cauwenberghe
Reference: Technology Overview Report TO-97-03, July 1997

The following technologies were identified and reviewed using the U.S. EPA REACHIT http://www.epareachit.org search engine:

Type: In-Situ Chemical treatment
Trade Name: TR-DETOX
Vendor: ETUS, Inc.

Type: In-Situ Chemical treatment
Trade Name: MAECTITE
Vendor: Sevenson Environmental Services, Inc.

Type: In-Situ Electrokinetic Treatment
Trade Name: Pool Process™
Vendor: Geokinetics International, Inc..

Type: In-Situ Stabilization
Vendor: AGEC

Type : In-Situ Adsorption
Trade Name: Forager™ Sponge
Vendor: Dynaphore, Inc.

Type: Delivery/Extraction System for In-Situ Injection
Trade Name: Mectool
Vendor: Hayward Baker, Inc.